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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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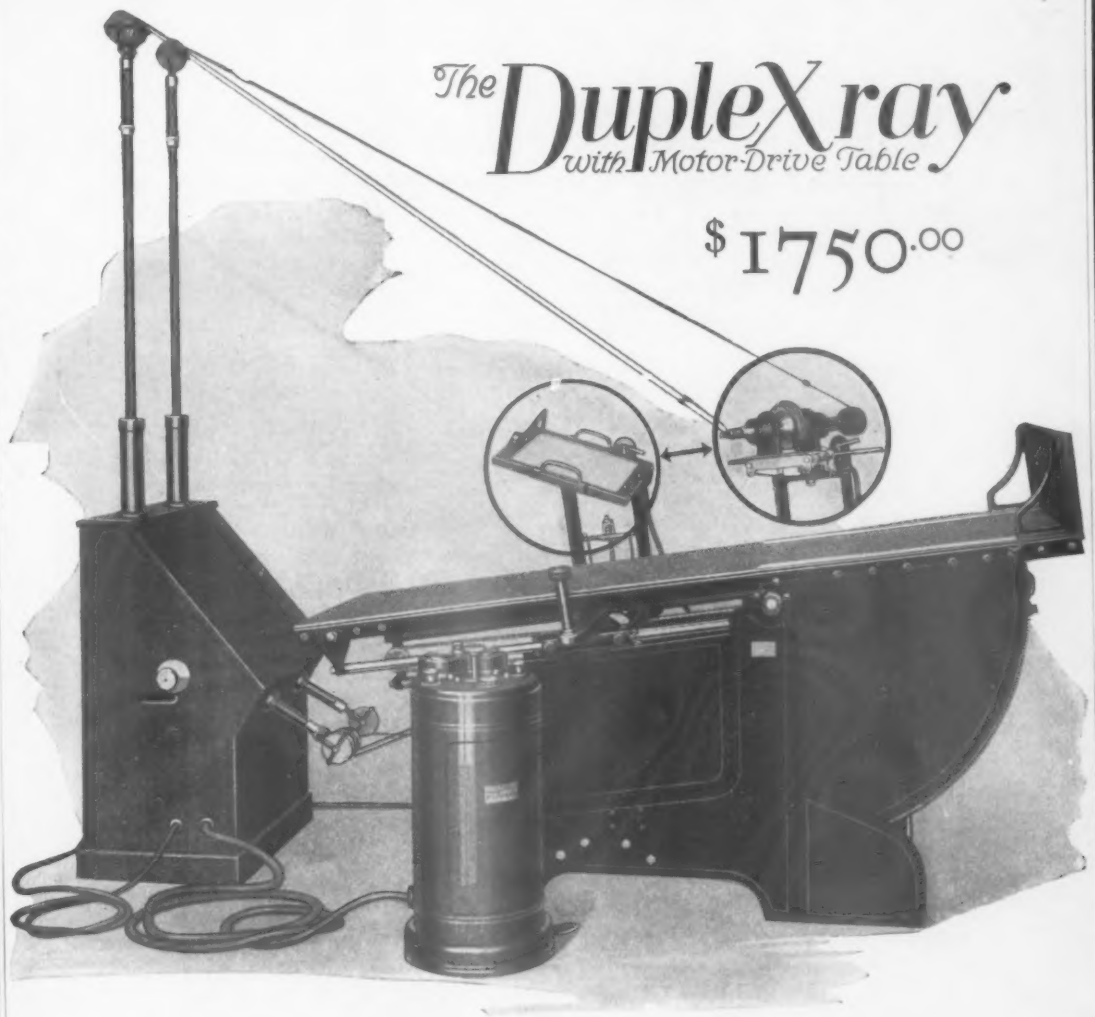

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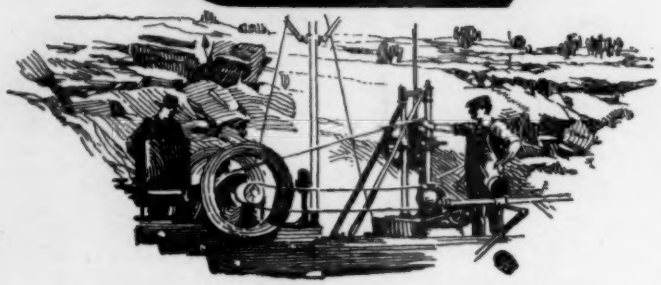

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VOL. X JANUARY, 1923 NO. 1

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. X JANUARY, 1923 No. 1

NEWER INVESTIGATIONS OF THE PROBLEM OF ROENTGEN-RAY DOSAGE*

BY OTTO GLASSER, PH.D.

BALTIMORE, MARYLAND

GRATEFUL acknowledgment is due your society for this opportunity of presenting the results of the investigations carried out with my honored chief, Prof. Friedrich, of Freiburg. Lack of time prevents a detailed report here of our work, but I would like to call your attention to our article[1] which contains the complete results.

Although ten years have passed since the appearance of the classical work of Christen,[2] on the problem of roentgen-ray dosage, there are still many questions which are not clearly understood. This uncertainty attaches not only to the working out of practical means of determining the dosage, but also exists in reference to the purely mathematical formulating of a dosage law. Since, however, the question of dosage is evermore to the front, Prof. Friedrich and I have decided to combine a general discussion of the entire problem with the report of our investigations. In these investigations there has been maintained a sharp distinction between the problems of *absolute dosage* and of *relative (practical) dosage*. The solution of the problem of absolute or scientific dosage, built upon the knowledge of the mechanism of ray-effect, should lead to the construction of an ideal dose-measuring apparatus. A modest contribution to the solution of this complicated question is what I here propose to present to you. In the next paper, Prof. Friedrich[3] will consider the entire problem of dosage. There, the help of the most modern conceptions of physics is utilized to illuminate the obscurity of both the absolute and the relative dosage.

For measuring ray-dosage, Kroenig and Friedrich[4] developed a method which depends upon ionization measurements; and this led to the construction of the iontoquantimeter. From a study of the absorption and ray diminution, they concluded that it was possible to construct an ionization chamber out of electrodes and gases of low specific gravity; and these apparatuses sufficed to compare measurements of rays of different wave-lengths. Their conclusions appeared to be supported by the agreement of the measurements obtained with little ionization chambers and those obtained with the so-called wall-less chamber, which latter is effected only by the secondary beta rays developed in the gas. These conclusions have now been questioned from various sources, especially on account of the fact that the knowledge of the scattering of roentgen rays and energy-relationships of the secondary beta rays has been greatly increased. Investigations showed that the capacity of the wall-less chamber of Friedrich was too small for the comparison of the range of the secondary beta rays coming from the hard roentgen rays. As a consequence, the measured electrical effect was too small for the hard, as compared with the soft, rays. As early as 1914, Duane[5] called atten-

*Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

tion to the fact that large ionization chambers must be used to measure the whole ionization effect of the secondary beta rays. But ionization chambers, even of the size recommended by Duane, were not large enough to measure the effect when using the short wave-length rays. This fact led Holthusen[6] to the construction of very large ionization chambers; it is also Holthusen, who, through a series of noteworthy works, showed the importance of the secondary beta rays on the dosage measuring apparatus. In the Radiological Institute of the University of Freiburg, we had already begun to work on similar problems before the appearance of Holthusen's publications, and only a brief report has been possible; this was given at the "Deutsche Roentgentagung" of 1920 in Berlin.

If one starts with the hypothesis that the number of ions produced from the secondary beta rays, developed from the roentgen rays in a definite radiated volume, is a measure of biological effect, then care must be taken that the full amount of these ions be measured. Since we, in our investigations, employed roentgen rays corresponding to an average wave-length of about .16 ÅU developed from a tension of about 200 kv., therefore, an ionization chamber of corresponding magnitude must be chosen. Since the range of the beta rays expelled from these hard roentgen rays is more than 15 cm., only a large chamber can measure the full electrical effect of these rays. The construction of our ionization chamber met these requirements. I can only briefly describe the measuring apparatus. Figure 1 shows a small diagram of the apparatus. F is the large zinc wall ionization chamber and K the small horn chamber of Kroenig and Friedrich. The length of the large chamber is 35 cm., the width is 32 cm. In the center of the large ionization chamber is an electrode of graphited paper in the form of a ring, r, which arrangement is favorable for the electrical field distribution. The interior electrode of the horn chamber is a graphite pencil. From both electrodes there run well-insulated connections over the switch Sch to the Wulf electrometer El. From the entire roentgen-ray bundle from the tube R, two small equal bundles are separated by the lead screens B, through which conveniently placed holes have been made. One bundle goes to the larger chamber and the other to the smaller. In a conveniently arranged holder on the lead screen, filters of various materials and thicknesses can be brought over the holes. Figure 2 shows the arrangements of the two chambers.

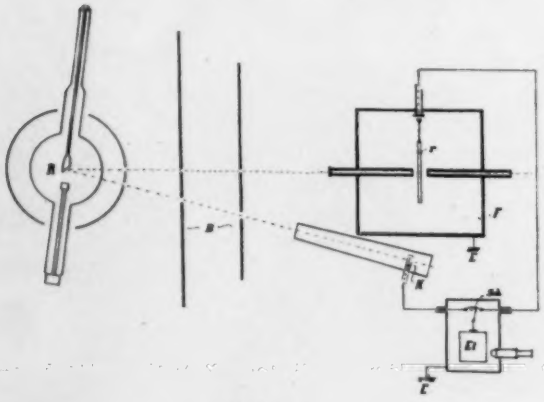

FIG. 1.

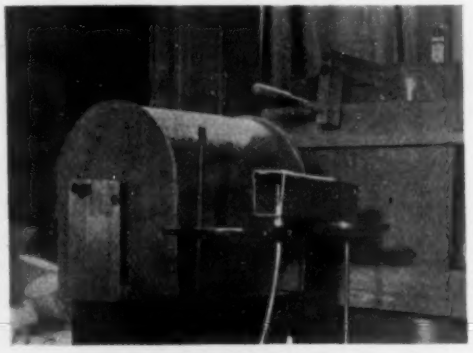

FIG. 2.

All parts of the apparatus are electrostatically protected and grounded in the very best manner possible; against adventitious rays, a thick lead housing is put over all parts of the apparatus. The tube R is a Coolidge tube with tungsten target operated with a "Sanitas-Hartstrahl Apparat." The cathode filament is heated by a storage battery, which, with a constant regulated primary current permits of perfectly stable conditions. The process of the measuring was that in general use. The time of the fall of the quartz thread through a definite part of the scale of the

electrometer was noted both for the large and small chambers under varying conditions; the values obtained for the large chamber were divided by those of the smaller chamber. Of course, all sources of error of this electrostatic arrangement were exactly determined. The actual readings were corrected mathematically, in order to remove these sources of error. Great care was taken to avoid any errors in the reading of the ionization current in the two chambers, due to the azimuth effect of the tube. For the investigations, 5 separate ranges of wave-lengths, determined by sphere-gap measurements and spectrograms, were employed. These groups are represented as H_1, H_2, H_3, H_4, H_5, and correspond to average wave-lengths of .43, .32, .25, .20, .16 Ångström units. An accurate description of the measuring apparatus, of the sources of error, etc., has appeared in the above-mentioned report.[1]

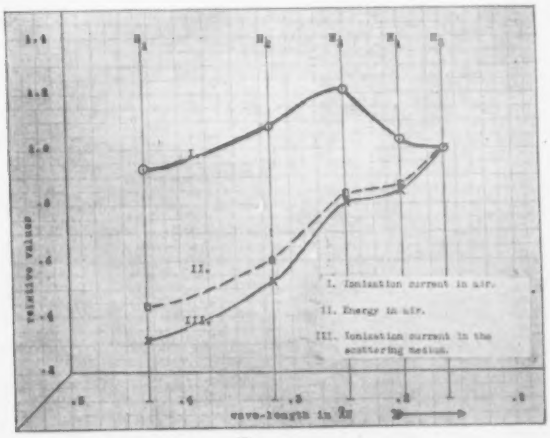
relative values
wave-length in Å
I. Ionization current in air.
II. Energy in air.
III. Ionization current in the scattering medium.

FIG. 3.

We will pass directly to the result of a comparison of the Friedrich horn chamber with the large ionization chamber, and pass over the technique of the experiments. Figure 3 shows three curves. The abscissae represent the wave-lengths; the particular average wave-lengths H_1 to H_5 used are marked. The ordinates represent the values of the quotient when the results of the small ionization chamber are divided by those of the large in relation to the value of the hardest rays H_5.

Curve I represents the values of the ionization currents in the small and large chambers, thus showing the errors made by the small chamber measurements. One sees that the quotient at first goes up with shorter and shorter wave-lengths, and then becomes smaller again. The variations from the quotient 1, are due to the fact that the amount of radiation from the walls of the small chamber increases with the shorter wave-lengths, whereby a stronger ionization takes place in the small ionization chamber. If there were no sources of error in the small chamber measurements, the results would be identical with those obtained by the large chambers, and the quotient would be one. Further shortening of the wave-lengths increases the range of the wall radiation beyond the diameter of the small chamber, and therefore, the secondary beta rays cannot produce their complete ionization effects: the quotient of the ionization currents becomes smaller.

Curve II in Figure 3 takes a different course. It represents the values of the quotients of the energies of the secondary beta rays for the larger and smaller chambers. These energy values can be directly calculated by the ionization currents, by means of the dependence of the ionization upon the energy of the secondary beta rays on the one hand, and from the Planck-Einstein formula (verified by Duane and Hunt), on the other hand. This energy curve shows that with the shorter wave-lengths, the energy, as measured by the small chamber, in comparison to the ionization effect, steadily increases.

I have shown these two curves because they are characteristic of two theories of dose measuring, i.e., the ion theory and the energy theory. The first states that the number of ions produced in an ionization chamber affords a measure of biological effect, the second that the energy of the secondary beta rays affords a measurement of the biological effect.*

What, according to our measuring results, can be expected as to a determination of dosage by small ionization chambers?

For measuring dosage of differing wave-lengths, the small chamber, at first sight, does not satisfy either theory; e. g., what does curve I show about dosage from the ion theory standpoint?

* See the investigations of G. Failla,[7] and others.

In the region of the soft rays (up to .34 AU) the dose as measured by the small horn chamber with increased hardness would be too great. As a result, the biological object radiated would receive, with shorter wave-lengths, too small a dose as compared with the soft rays. As a result of this, as measured by the horn chamber, the short wave-length rays seem to have less biological effect than the longer wave-length rays. In the region of the hard rays (beyond .34 AU), one sees that the curve 1 falls again, and therefore, with shorter wave-lengths the dose as shown by the measuring apparatus is too small. Consequently the dose to a biological object as compared to relatively softer rays is too great. Therefore the extremely short wave-lengths would have a more favorable effect.*

Let us now pass to the dosage by the energy measuring of the secondary beta rays. Curve 11 shows here that the measured energy steadily rises with shorter wave-lengths. It is evident that the short rays would produce here in the horn chamber much more effect than the long waves, and that, as a consequence, a biological object will receive too small a dose if short waves are used.

To sum up: it is evident that in the construction of biological rules determined by small ionization chamber measurements, it is necessary to make certain corrections, whether the ion theory or the energy theory is employed.

As a matter of fact, series of such biological rules are in existence, on the one hand, from the ionization standpoint, and on the other, from the energy standpoint; the first group is fairly represented by Kroenig and Friedrich,[4] and the second by Holthusen.[6]

In order to test these two theories, Holthusen conducted a series of investigations in which he standardized his small aluminum chamber by means of a large chamber. By this means he was able to show that in radiating the "Ascaris megalocephalus" the energy theory will agree with the biological effect, quite independent of the wave-lengths employed. In contrast with this, an assumption of the ion theory showed that there was a quality difference between the different wave-length doses, in the sense that the short wave-length rays seemed to be less effective.

Very different conclusions were reached by Kroenig and Friedrich, who, in their well-known biological investigations in determining dosage only by measuring the ionization current in the small horn chamber, found no dependence of biological effect upon wave-length; these experiments were made upon plant, animal and human tissues.

This discrepancy has been much discussed and misunderstood and the results of the investigators have been repeatedly put under suspicion. The apparent disagreement of these results is explainable, if one takes into consideration the additional dose of the scattered radiation, which takes place in the radiated medium.

Holthusen employed for his investigations as small a test object as possible; he did this from theoretical considerations, in order to have conditions as nearly as possible like those in the ionization chamber. The use of larger objects—in particular, the human tissue by Kroenig and Friedrich—corresponds more closely to the practical use of the rays, but adds to the direct radiation a marked amount of scattered radiation. Smaller test objects (tadpoles and germinating beans) were intentionally radiated in large water vessels, in order to reproduce exactly the same conditions as to the scattered radiation.

We measured, with the apparatus described above, the scattered radiation for the region of the wave-lengths H_1 to H_5 by putting the small ionization chamber down into the scattering medium; it is evident that the scattered radiation has a great influence upon the consideration already mentioned in connection with the ionization curve 1 in Figure 3. This influence of the scattered radiation, added to the direct radiation, both measured by the ionization current in the small chamber, is shown in curve 111 in Figure 3. It is apparent that this curve takes an entirely different course with shortening wave-length from that shown in curve 1, which

* These results have been in part reported also by other observers, and it is therefore urgently necessary, in comparing their results with ours, to have the exact data as to the range of wave-lengths used.

shows the ionization current measured in air. *Moreover, it is evident that the ionization measurements made in the scattering medium* (see curve III) *correspond to the measurements of energy made in the air* (see curve II).

By way of résumé, allow me to repeat that Holthusen employed test objects of very small size, and came to the conclusion that the biological effect was independent of the wave-length over a definite scale of wave-lengths, when he applied a definite correction factor, and by this means calculated the ionization currents in terms of energy. In contrast with this, there was a distinct difference in biological effect, when measured by the ionization current alone. Kroenig and Friedrich used large test objects and dosed by the ionization current measurements. It is evident (see curve II, showing the energy, and curve III, the ionization, in the scattering medium) from our investigations that the additional effect of the scattered radiation approximately equals the correction factors employed by Holthusen for estimating the energy of the secondary beta rays. As a result of this, the direct readings by Kroenig and Friedrich *automatically supply the right correction, and the applied dose is the same as by the energy theory.*

Our investigations would not be complete if we neglected to consider chambers of other materials; for instance, of materials which can easily be sterilized and are of low atomic weight. I will limit myself, however, to a consideration of an aluminum chamber of ⅛ mm. wall thickness and to a very thin graphited paper chamber. In the case of the aluminum chamber, the course of the three curves is very similar to that obtained with the horn chamber. However, the maximum is higher, due to the fact of the greater influence of the wall rays. Of interest are the results of the measurements shown when the aluminum chamber was brought into a large scattering medium. It was found, as was known formerly, that there must be a difference in biological effect with different wave-lengths when one employs the ionization currents as a measure of dose.

Where a thin graphited chamber is used as ionization chamber the three curves are not so very different from each other. The biological results obtained by the two theories would here be almost identical.

I will not detain you longer now, but refer you to the detailed report in *Strahlentherapie.*

I hope, however, that this short presentation has given you an understanding of the great importance of these questions of dosage. You see that our investigations not only present an accurate and critical picture of what takes place in the small ionization chambers, but they may, perhaps, throw light upon the essential biological action of the rays in tissue.

This represents the most pressing problem immediately before us today.

BIBLIOGRAPHY

1. Friedrich, W. and Glasser, O. Untersuchungen und Betrachtungen über das Problem der Dosimetric. *Strahlentherapie,* 1922, xiv.
2. Christen, Th. Messung und Dosierung der Roentgenstrahlen. Hamburg, 1913.
3. Friedrich, W. The problem of ray dosage. Am. J. Roentgenol., 1923, x, 1.
4. Kroenig, B. and Friedrich, W. Die physikalischen und biologischen Grundlagen der Strahlentherapie. Berlin, 1918. English edition, New York, 1922.
5. Duane, W. Meeting of The American Roentgen Ray Society at Cleveland, Ohio, 1914.
6. Holthusen, H. *Fortschr. a. d. Geb. d. Röntgenstrahlen,* 1919, xxvi and xxvii.
7. Failla, G., Quimby, E. and Dean, A. Some problems of radiation therapy. Am. J. Roentgenol., Aug., 1922, ix, 8.

THE PROBLEM OF RAY DOSAGE*

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WE greatly appreciate this opportunity of laying before you some of our thoughts about ray dosage.

In the paper of my collaborator, Glasser, you have heard of a series of investigations which showed that there are entirely contradictory biological effects according to the working hypothesis applied to interpretation measurement of ray dose, independent of wave-length. It seems opportune to explain the theory of dosage itself before beginning a general discussion of the subject. Christen expressed the conception of the dose which a little volume of any radiated medium receives, by the formula

$$1.\quad D = \frac{I \times t}{h}$$

This is the so-called "physical dose," and does not take into account the transformations of energy which lead directly to biological effect; Christen accounted for this by adding a factor σ to the physical dose. This factor shows the part that this dose has in the direct biological effect.

Our conceptions today as to the nature of the emission and absorption of rays have been influenced through a series of investigations expressed in the Einstein-Planck formula (verified by Duane and Hunt).

$$V \times e = h \times \nu$$

$$2.\quad \tfrac{1}{2} m \times v^2 = h \times \nu$$

It is, therefore, necessary to define more precisely our conception of intensity. (In the Einstein formula, V denotes the maximum tension, e the elementary quantity of electricity, h the Planck constant, ν the frequency of the rays, m the electromagnetic plus the real mass of the electron, v its velocity.)

By the intensity of radiation is meant the energy falling upon a unit of surface in the unit of time; this may be written

$$3.\quad I = \frac{E}{f \times t}$$

The problem is now to determine the value of the energy E. Simple explanations seemed necessary, as the non-physicist is the person who will be practically interested in these considerations. For this reason, the process of the origin of the non-characteristic roentgen rays and the distribution of the energy they give rise to, will not be considered, since as yet these processes have not been completely investigated. They are very complicated and not essential to the discussion of the problem.

Let us imagine, therefore, a non-polarized monochromatic radiation, such as, for example, in one of the spectrum lines of the target material of a tube. Let the energy of the roentgen rays produced by the energy of a beta ray of $h \times \nu$ be $h \times \nu$. This energy is distributed upon a spherical surface whose center is the anticathode, and propagates itself with the velocity of light. In a square cm. we therefore have a surface energy of this elementary radiation of

$$4.\quad F = \frac{h \times \nu}{f} = \frac{h \times \nu}{4\pi r^2}$$

The energy produced during any period of radiation is evidently proportional to the number of elementary radiation processes; accordingly

$$5.\quad F_n = n \frac{h \times \nu}{4\pi r^2}$$

For the energy emanating in the unit of time through the unit of area, in other words, the intensity, we can accordingly write the formula

$$6.\quad I = \frac{n \times h}{4\pi r^2 t}$$

If we add the duration of radiation, there results the equation

$$F_n = I \times t$$

There is still another important factor, i.e., the absorption coefficient of the object radiated. By this is meant the reciprocal thickness of a layer necessary to absorb the radiation applied, to the e^{th} part. This is expressed in the well-known law of absorp-

$$7.\quad I_d = I_o \times e^{-\mu d}$$

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tion in which I_o and I_d represent respectively the impinging and the radiation passing from the medium, d the thickness of the penetrated layer, μ the coefficient of absorption and e the base of the hyperbolic system of logarithm.

If a radiation of the surface energy expressed by formula 5 falls upon a small unit volume of the absorbing substance which is of d thickness, then the dose received per unit of surface will be

$$8. \quad D = F - F_o$$

$$\text{i.e. } D = \frac{n.h.\nu}{4\pi r^2}\left(1 - e^{-\mu d}\right)$$

In the above formula the influence of the inverse square law has not been taken account of.

Scattering. A part of the entering energy of a roentgen-ray bundle is transformed in passing through a medium to some extent into scattered radiation. Another part of this entering energy is absorbed in the production and driving of the secondary beta rays. This latter portion is now-a-days referred to as absorbed energy and in the formula is expressed by μ. It is only in recent years and by the use of very penetrating rays that the importance of these factors in practical dosage has been recognized.

Since the scattering radiation in any medium larger than a single atom gives rise to an exactly similar dosage in surrounding atoms, it is obvious that this simple characteristic dosage formula cannot be maintained. The additional dosage dependent on scattered radiation must be expressed by a definite factor. An attempt to fix mathematically the amount of additional dose due to scattered radiation as reported by Glocker and his collaborators complicates and well-nigh makes impossible a single presentation of the subject. The factors which determine the dosage are the same as in the direct dose just explained, but the functions are greatly complicated by the different distances of the centers of scattering, and the consequent different thicknesses of medium passed through. Suffice it to say that the additional dose constitutes a function of the scattering, and can be expressed by

$$9. \quad D_2 = f(S)$$

For the total dose received by a volume element at a distance r from the source of radiation we get the formula

$$10. \quad D = \frac{n.h.\nu.t}{4\pi r^2 t}(1 - e^{-\mu d}) + D_2$$

$$\text{i.e. } D = (I_a + I_s).t.(1 - e^{-\mu d})$$

Accordingly the dose is proportional to the total intensity $I_a + I_s$ (I_a is the direct, I_s the scattering intensity) entering the volume; it is furthermore proportional to the time of radiation t, and to the absorption coefficient μ, or, expressed in another way, inversely proportional to the half value layer.

It is evident that the essentials of Christen's formula are preserved; the introduction of the expression $h \times \nu$ makes possible a much more detailed consideration of the relation which exists between the energy of radiation and that of absorption. We shall not discuss this here, however.

Problem of Dosage. The problem of dosage is the development of means and methods which will permit of actual measurements of the values theoretically defined in the preceding paragraphs. During a radiation the observable changes that take place in a living object are practically nil; they develop some time after the radiation. There is, therefore, no biological method for directly measuring the dose. For this reason it is necessary to turn to chemistry and physics for additional help.

It is essential, just as in case of every measurement of energy, that one or more energy transformations be followed and measured. The measuring apparatus should contain, as a chief constituent, a substance that is changeable under the influence of radiation energy. It is evident that the transformations which take place in the measuring apparatus should be the same as those in the material to which the dose is applied. For the most part, these are living objects, and identical changes are, of course, not always obtainable. But at any rate, the transformation of energy must conform to the same laws with reference to the dependence of measurable transformations of energy proportional to the determining of factors. It is essential that the measuring apparatus and the test object should absorb the rays, whatever the wave-length may be

proportionally, in order that the apparatus may be used as a practical instrument when rays of different wave-lengths are employed. In order to find a test object which will meet the needed conditions, it is essential to understand the effect of the radiation in a biological object. Unfortunately, the numerous previous investigations in this line afford us little help. The processes underlying the simplest photochemical changes in non-living substances produced by roentgen rays or light are not completely understood. In the absence of clearly understood processes we are, therefore, in the working out of a process of dosage measurement, limited, for the present, to hypothesis. As an illustration, Glasser has just shown that the hypothesis may be maintained that the number of ions formed in the biological object during radiation—in other words, the electrical effect—determines the biological change. Under this hypothesis it is first necessary to secure a measuring substance which permits the number of ions formed in it to be measured. It must furthermore satisfy other demands; for example, the conditions of absorption and scattering must be identical or directly proportional to those taking place in the living object tested. Air is such a test body. Providing that a definite size of such a test body and uniform conditions be maintained in relation to the biological object to be measured, it is possible to establish a measure of dosage of varying wave-lengths, and to formulate rules which permit of the determination of the extent of the biological effect from any given amount of any wave-length. It was clear from Glasser's paper that where this hypothesis is employed, hard rays seem to have a less biological effect than soft rays, but also that scattering rays lead to deviations from the rule.

It is possible to work with another hypothesis which is also very plausible, i.e., that the energy of the secondary beta rays determines the biological effect; in the paper of Glasser it has been shown that the energy of the secondary beta rays and the number of ions formed by radiation do not run parallel when waves of different lengths are tested.

It is evident that when this energy theory is employed, a method must be devised that permits of energy measurements. You have seen that it is possible to construct a measuring apparatus which meets this need, provided that certain fixed factors are recognized and corrected for. The rules of dosage formed by this method do not agree with those deduced from the ion theory when they are applied to a determination of the amount of biological effect with rays of different wave-lengths.

Furthermore, still other hypotheses are possible; for example, it may be assumed that the roentgen rays have a direct biological effect without the formation of electrons; this is supported by the investigations of Lenard and Ramsauer, which showed that photochemical processes take place under the influence of light without the formation of ions.

A further important factor is the size of the radiated biological object. The biological effect in a small object where a definite intensity of a definite wave-length is used is quite different from that in large objects under the same conditions. Further investigations which will show the influence of volume upon the dose are greatly needed. It should be firmly held in mind that the principles of dosage measurements given have taken into account only the "density of the dose."

These simple examples show how difficult the solution of the *absolute dosage* problem is. It can only be attained by thorough systematic investigation, in which physicists, chemists and biologists must cooperate in creating the foundations. It is important to study *in vitro* all known processes which may in any way play a part in the biological changes induced by radiation. Phenomena of like kind must be brought together under definite rules. When these processes are clearly understood under the simpler conditions, then it will be possible to apply them to a study in the living organism. It is quite certain that the immediate future is not likely to show what these biological effects are. We have merely to think of the multitude of complex catalytic and fermentative processes which take place in the living body, to realize the magnitude of the task.

It is an incentive to systematic and thorough work to realize that these problems once solved will have a tremendous influence on the practical employment of roentgen rays as a therapeutic agent.

Practical (relative) Dosage. It is, of course, not possible to defer the entire practical application of roentgen-ray therapy until perfect measuring apparatus is developed. The conditions required for practical dosage are entirely different from those above outlined. Practical medicine seeks to put into reproduceable form the biological phenomena established by experience. From this point of view, much less severe demands are made upon a measuring device. There are two main requirements: (1) The instrument must be sufficiently sensitive to record small differences in dosage used in practice; (2) the instrument must be reliable, so that under the same conditions of radiation it will always record the same results. These processes do not measure the dosage in the above-defined theoretical sense. For the sake of simplicity, however, we shall designate the magnitude measured as dosage.

Dosage-measuring Apparatus. The processes used in medicine for measuring dosage meet these two demands in a greater or lesser degree. One may divide them into two groups:

1. Measuring the dosage at the point where the effect is desired.

2. Measuring the working conditions, which include calibration of tubes and apparatus.

The old methods of dosage, such as the Kienboeck strip and the Sabouraud-Noiré tablets are today considered unreliable on account of their lack of sensitiveness.

Modern measuring methods are based upon measuring the change in resistance of selenium (Fuerstenau intensimeter) or on measurement of ionization. The latter processes are recognized as more reliable. The construction of the ionization apparatus has reached such a degree of simplicity that it may be competently used by those who are not physicists.

The instruments to be mentioned here are the "iontoquantimeter" with the small horn ionization chamber previously described, the aluminum chamber with galvanometer of Duane, the "iontoquantimeter" as invented by Hammer, the "iontoquantimeter" of the Standard *X*-Ray Co., the "ionometer" invented by Wulf, the "Siemens Roentgen dosimeter," the "Veifa Electroscope," the "ionimeter," by Martius, the *x*-ray measuring apparatus of Roy Kegerreis, and others.

The first method, that is, measuring the dose at the point where the effect is desired (direct dosage) is carried out by these instruments partly in the form of a permanent measurement. For example, the iontoquantimeter measures the dosage for the entire duration of the radiation, and thus takes account of all the variations in the conditions of operation. With instruments of the Veifa electroscope type, the measurements must be made before or after the treatment; and with tubes of the Coolidge type, the results are dependable.

In the second method, it is necessary to determine the working conditions of tube and apparatus, which factors are necessary to compute the dosage. These factors must include the strength of current and the tension or hardness, and the knowledge of the technique of radiation and filtration. The second method also includes measurements, which, with the aid of a water phantom, or one of wax or wood, furnish data concerning the distribution of the intensity or of the dosage at the surface and in the interior of the object to be radiated. The use of these measurements in phantoms demands a verification of the constancy of the conditions of operation when they are employed for the biological object. Since the technique always remains the same in the case of a number of objects which are subjected to radiation, especially in gynecology, the results once obtained for a given case have been tabulated to indicate the distribution of intensity (e.g., see charts of Dessauer and Vierheller or tables of Duane or others) so as to avoid constant repetition of the same measurements with phantoms. Such tables can be used directly for radiation purposes, since the conditions of measurements are the same.

Finally, a combination of both methods may be employed. This consists in the fact that the first method measures the

dosage on the surface of the object to be radiated, and the second method gives the data concerning the rays to be employed and other conditions (size of field, focus skin distance, etc.) and enables one to draw conclusions as to the distribution of the intensity in the object radiated.

In conclusion, let us point out once more the importance of an exact formulation of the problem of dosage. In the above presentation we intentionally drew a sharp line of demarcation between the problems of *absolute dosage* and *relative dosage* of roentgen rays. All the investigations concerning the question of *absolute dosage* were undertaken to throw light upon the possibility of the establishment of an absolutely exact method to measure the dosage. In order to attain this, a knowledge of the nature of the action of the rays is absolutely essential. Only then will it be possible to discover further laws concerning the biological effect of rays of different degrees of hardness; that it can be attained only by systematic research work we have already demonstrated.

The *relative dosage* methods of medical practice are suitable to give the practitioner, the clinical expert, and the radiotherapist the possibility of attaining reproducible physical conditions in the clinical applications of the rays. Naturally, various investigations can also be made with these measuring processes, and various biological problems can be solved; under this head may be grouped all those questions which concern radiation effects of a given degree of hardness. In all investigations where rays of different degrees of hardness are compared with each other by means of one of these dosage processes, be it by the theory of energy, the ion theory, or a chemical theory, no absolute laws can be posted at present, especially since the biological results obtained on the basis of the theory may yet be influenced by technique. At present we cannot give preference to one or another theory.

To continue investigation of *absolute dosage* is the chief task of the physicist in collaboration with the biologist and the chemist; independent investigation will hardly lead to the goal. In the matter of *practical dosage*, the physicist has done his part for the time being; now it is the task of the clinical investigator to continue the work along these lines.

INTESTINAL REACTION TO ERYTHEMA DOSE*

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TO the student it must be evident that the recent rapid strides of roentgen-ray therapy have uncovered many long lanes of research that deserve careful and painstaking investigation. It is to be regretted that the field of biological research is not advancing as rapidly as that of electrophysics, since all rational *x*-ray therapy must be based on our knowledge of biological reactions to radiation.

At the present writing, it seems that no one portion of the body offers more of interest from the *x*-ray point of view than the gastrointestinal tract. There can be little doubt that the intestine plays a definite rôle in at least one form of roentgen-ray toxemia. Denis, Martin and Aldrich[1] described, in 1920, the results obtained following the regional radiation of animals. It was pointed out that a certain dose of *x*-rays would produce the death of a rabbit only when delivered over some portion of the intestinal tract. When this same dose was administered to the chest or to the hind legs, no noticeable reaction was observed. Warren and Whipple[2] have repeated these experiments, using dogs instead of rabbits, and have reported similar results. They have also made a careful histological study of the intestine falling within the region of exposure, and report that many areas show a complete absence of epithelium. These workers state: "The epithelium of the small intestine from the pylorus to the ileocecal valve is remarkably sensitive to the roentgen rays. . . . We may infer that the *x*-rays may produce sublethal injury to this intestinal epithelium which may be responsible for a variety of disturbances associated with gastrointestinal symptoms." The same investigators call attention to the similarity of the symptoms of roentgen-ray toxemia to those observed in experimental intestinal obstruction.

Dragstedt, Moorhead and Burcky,[3] after studying the rapid death of dogs with isolated artificially prepared closed intestinal loops, make the following statements: "Thus it is probable that bacteria alone, or in connection with the contents of the lumen of the intestine, do not give rise to the toxemia of obstruction when they are separated from the blood by the cells of the intestinal mucosa. However, a combination of these two factors (necrotic tissue plus putrefactive intestinal bacteria) rapidly gives rise to fatal toxemia."

The practical significance of intestinal reactions was rather forcefully brought to our attention a few months ago when one of our patients developed a bloody diarrhea, following the application of a heavy dose of rays to the lower abdomen. A nodule about 2 in. in diameter had appeared in the abdominal wall several months after a hysterectomy for carcinoma of the fundus of the uterus. A dose of 600 ma. min. at a target-skin distance of 12 in. was delivered to an area of skin 8 in. square, with a sphere gap reading of 140 kv. A filter consisting of ½ mm. of copper and 1 mm. of aluminum was used. The skin reaction was rather severe, and was soon followed by the passage of blood per rectum, which continued for several months. The patient seems to have suffered no permanent inconvenience from this occurrence.

However, more serious results have been reported in the foreign literature. Beclere,[4] in discussing the treatment of a case of carcinoma of the cervix, states that a condition like dysentery was set up with bloody stools, colonic perforation and stenoses. Fischer[5] describes 3 cases of fatal necrosis of the intestine following the use of deep therapy in the treatment of abdominal tumors. He emphasizes the fact that the intestine is easily injured where the abdomen is exposed to crossfiring.

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

The above observations justify a careful study of the sensitiveness of the intestine to radiation. Different authors have estimated the carcinoma dose as 100 to 140 per cent of the erythema dose. Some data should be obtained relative to the effect of the erythema dose and various fractions thereof on the intestinal tract, before an attempt is made to treat tumors situated in the abdominal cavity by deep radiation. It is true that many writers claim that they are delivering as high as 110 per cent of the erythema dose into the abdominal cavity without mishap, but it must be remembered that this measurement is based entirely on physical instruments and calculations, and not on the actual reaction of the living cells in the depths of the tissues.

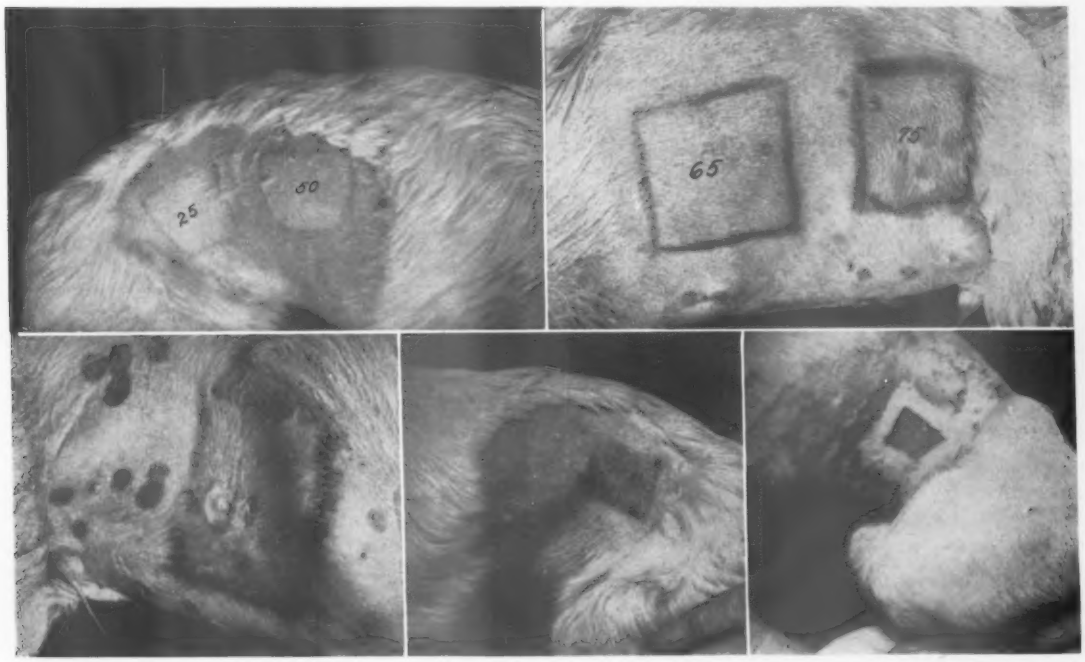
In an effort to throw some light on this subject, a series of experiments was mapped out in which no physical measuring devices were necessary. Animals were operated upon under ether in the *x*-ray laboratory, and loops of intestine laid out on the abdominal wall, so that the intestine and the skin received the same quantity of *x*-rays. The animals were then closed up and allowed to recover from the operation. Obviously, it was quite easy to read the dose of rays received by the exposed intestinal loop in terms of the skin erythema dose at the end of ten to fourteen days.

In deciding upon a technique for this work, a parallel gap of 5 in. was adopted, and no filters were used except a thick piece of paper, which kept the heat and light from the target from striking the exposed viscera. It might be the feeling of some that only short wave-lengths should be used in dealing with deep therapy problems. It seems, however, that the reaction of living cells is dependent only on the quantity of rays absorbed, regardless of the wave-lengths. Thus Kroenig and Friedrich[6] state: "Within the limits of hardness of the radiations investigated, the intensity of the biologic action is independent of the hardness of the rays; the intensity of the biologic action is only dependent on the radiation energy absorbed." Heavily filtered doses were impractical, because it would have been difficult to keep animals in good condition after leaving the abdomen open for two

FIG. 1. Pathological loops of intestine found in animal that died four days after receiving 200 ma. min. over each flank.

or three hours, and a skin erythema could hardly have been obtained from a shorter exposure.

The spark-gap was determined by a point to point measurement at the beginning of the investigation, and the reading of the low tension voltmeter observed. At all subsequent experiments, the machine was set to give the same voltmeter reading, regardless of what the point gap might be. This gap measurement was found to vary from 5 to 5¼ in. on different days. A sphere-gap used at the beginning of the work showed a definite sparking over or 9 in. has been used. In order to compare the effect of a 5 in. back-up, a dog of medium size was given a dose of 200 ma. min. over each flank. Areas 3½ in. square were used, and the remainder of the dog's body was shielded with lead foil. On the third day, this animal refused food and developed a diarrhea. On the morning of the fifth day it was found dead in its cage. Autopsy revealed the condition shown in Figure 1. Several loops of small bowel showed dilatation and a smoothing out of the normal convolutions. There was also a marked hyperemia made out in the



25 and 50 ma. min. 65 and 75 ma. min.
85 ma. min. 100 ma. min. 150 ma. min.

FIG. 2. Photographs of the skin reactions observed following the administration of various doses. Where the reactions are absent or faint, the exposed square is outlined with a skin pencil.

when adjusted to a reading of 75 peak kv. with the machine running at the setting just described.

All experiments were performed with a secondary current of 10 ma. read on 3 milliammeters of different makes connected in series. These instruments checked each other within ¼ ma. at this reading. A target-skin distance of 10 in. was used throughout the investigation.

In all the published work coming to our attention in which fatal doses have been delivered to animals, a parallel gap of 8

affected loops, and, in places, the intestinal wall showed definite thinning. The worst lesions were in the duodenum. This pathological picture is practically the same as that described by Warren and Whipple in experiments in which the higher voltages were used. A 5 in. gap was therefore adopted as suitable for the work in hand.

It was, of course, necessary to determine the erythema dose as accurately as possible before beginning the operative work. Unfortunately, the dog's skin, as well as that of all other experimental animals, is very

resistant to radiation. Areas 2½ in. square were marked off on the abdomens of three different white dogs, and doses of 25, 50, 65, 75, 85, 100 and 150 ma. min. administered. The skin of the exposed area was shaved in each instance. Figure 2 shows the reactions obtained.

The erythema, where it appeared, was always visible by the eleventh day. A very slight discoloration was observed over the area receiving 65 ma. min., but the area receiving 75 ma. min. was the first one in the ascending scale to show an unmistakable reaction. Seventy-five ma. min. was therefore accepted as the minimum erythema dose for the skin of a dog under the conditions stated above. This dose is more than three times the "erythema dose" for the human skin. One hundred ma. min. gave a reaction which approached the one commonly used in therapeutic work. The skin turned red in eleven days and then slowly became brown. At the end of a month, desquamation was in progress. There was no vesiculation or ulceration at any time. One hundred and fifty ma. min., which may be considered as double the minimum erythema dose, slowly developed a shallow ulceration, which was surrounded by a broad band of alopecia. At the end of six weeks the ulcerated area was crusted over and much contracted, and was beginning to heal. The burn produced by this dose was not of the serious "incurable" type, and might be taken to represent the "erythema dose" of the degree described by some of the most radical workers. It was deemed necessary to study a wide range of skin reactions, because deep therapists differ widely in their conceptions of the "erythema dose."

Since the mucosa has been shown to be the most sensitive portion of the intestinal tube, the question of the filtering effect of the muscular layers immediately arose. In other words, it was important to determine whether the dose delivered to the peritoneal surface of the intestine differed materially from that delivered to the mucosa. In studying this point, two squares measuring 3 in. on a side were marked off on the flank of a large brindle dog, and at the time of exposure a freshly-opened piece of small intestine from another animal was laid across the mid-portion of each area. Doses of 100 and 150 ma. min. were applied to the two areas. At the end of eleven days, there was a definite reaction over each square, but there was no detectible difference made out between the erythema of the skin that had been covered by intestine, and that which had not been covered. Figure 3 illustrates the results obtained.

From these observations it seems fair to assume that the filtering effect of the intestinal wall is too small to be taken into account, and that the dose delivered to the skin in the following experiments is practically the same as that delivered to the intestinal mucosa.

All the dogs submitted to operation received the same preparation. The skin of the operative field was shaved and cleansed with soap and water and ¼ gr. of morphia and 1/100 gr. of atropin sulphate were given subcutaneously about three hours before beginning the procedure. The medication provoked active emesis, defecation and urination, and was of great value in that the intestines were almost completely emptied. An operating table was set up in the *x*-ray laboratory, so that there was little delay in carrying out the whole procedure. Ether anesthesia was used for each experiment, and all precautions were taken to provide the most perfect asepsis possible. No iodine, bichloride of mercury or other irritants were used. The skin was sterilized with 70 per cent alcohol. This eliminates any skin sensitization.

In our laboratory, the "erythema dose" for the human skin as used in the treatment of cutaneous malignancy is taken to be 25 ma. min. for the settings adopted for this investigation. It was, therefore, thought advisable to study first the effect of this dose on the dog's intestine. The abdomen of a medium-sized female dog was opened. A sterile shield of lead foil was placed over the dog's body, so that a square hole measuring 2½ in. on a side lay over the incision. A loop of ileum measuring 12¼ in. in length was brought up through the hole in the shield and spread out over a layer of gauze moistened in warm normal salt solution. A second thin

layer of moist gauze was placed over the loop, to prevent drying. The edges of the wound were clipped together temporarily, so that there was a small area of skin directly exposed in the upper half of the hole in the shield. The appearance of the operative field is shown in Figure 4. The *x*-ray tube was swung over the intestinal loop and a dose of 25 ma. min. administered.

Following this procedure, sutures were placed in the mesentery at the ends of the exposed loop, as markers, the intestine was dropped back into the abdominal cavity and the incision closed. The abdomen was bandaged and the animal was placed in a clean cage. After two days the bandages were removed. At the end of three weeks the skin showed no evidence of a reaction and the dog appeared to be in excellent condition. Autopsy was performed. The exposed loop showed no gross abnormality, either on the serous surface or in the mucosa. The findings are illustrated in Figure 5. The human "erythema dose" is therefore too small to be of value in these experiments.

Seventy-five ma. min., the minimum erythema dose, was selected for the next experiment. A medium-sized dog was subjected to the same operative procedure as that described above, except that the loop of intestine exposed measured 17½ in. in length, and included the lower jejunum and upper ileum. The dog made an excellent recovery. A slight stitch infection caused the skin about the wound to remain moist during the first ten days. A faint erythema was observed on the eighth day over the exposed skin area. On the twelfth day, this region showed a deep red color. On the seventeenth day,

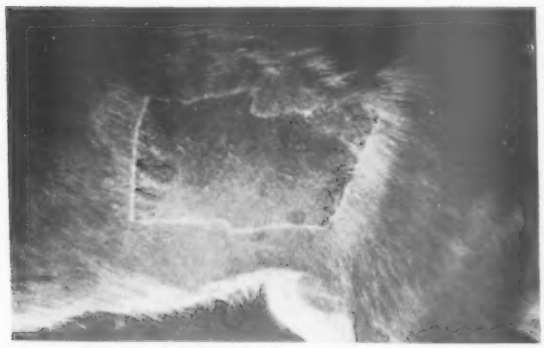


FIG. 3. Areas over parts of which strips of fresh intestine were placed before exposure. Note the uniformity of the reaction.

FIG. 4. The operative field just after the intestinal loop was drawn through the lead foil shield. A thin piece of wet gauze was placed over the intestine before radiation was begun.

FIG. 5. Open strip of intestine and area of skin which received 25 ma. min. There is no abnormality visible.

FIG. 6. Exposed strip of small intestine and skin area which received 75 ma. min., the minimum erythema dose for a dog.

the red color was observed to be fading, and on the twentieth day, no sign of the skin reaction could be made out, except an alopecia over the exposed area. At the end of three weeks autopsy was performed. The dog was very active and appeared to be in the best of health during the time of observation. No vomiting or diarrhea had been observed.

On opening the abdomen, the exposed loop could be identified by the smoothing out of the circular convolutions observed in the normal intestine, and also by a hyperemia due to the injection of the subserous vessels. However, the most striking change was the marked shortening of the loop. The distance between the markers was just 6¼ in., whereas at the time of exposure, this distance measured

FIG. 7. External appearance of loop of intestine receiving 100 ma. min. three weeks after exposure.

17¼ in. The contraction of the skin when subjected to an erythema dose was described by one of us in a previous paper.[7] Contraction appears to be an outstanding feature of roentgen-ray reactions.

When the loop was laid open, a pathological picture of such severity was revealed that it seemed hard to believe that this animal had been symptom-free. With the exception of an elongated patch near the mid-portion of the exposed region, the velvety appearance produced by the villi was absent. The inner surface of the intestine was smooth and dark red in color. Most of the epithelial layer had disappeared in the discolored areas. The limits of the roentgen-ray effect were sharply demarcated at the ends of the loop. There was no evidence of hemorrhage into the lumen of the bowel, which showed normally colored contents. The diameter of the lumen of the intestine was diminished. The appearance of the exposed bowel and the excellent condition of the skin of the exposed area (marked off with a skin pencil) are shown in Figure 6. Obviously, the minimum dose producing erythema of the dog skin produces considerable damage to the small intestine of the animal.

A small white dog was next subjected to a similar procedure, except that a loop

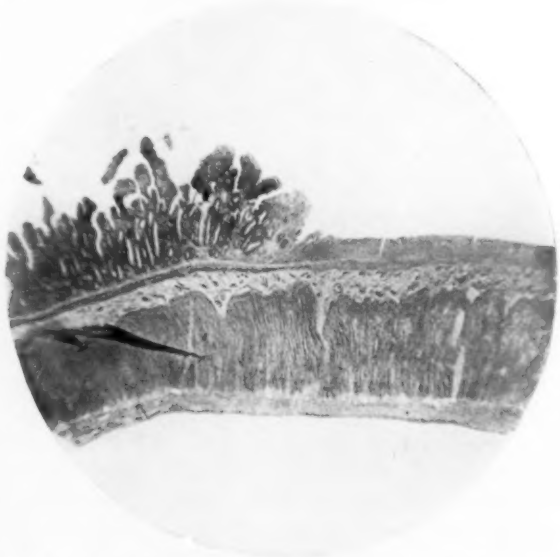


FIG. 8. Low-power view of longitudinal section of intestinal wall from exposed loop shown in Figure 7. Note the complete desquamation of epithelium over the involved region.

of small intestine measuring 5 in. in length was subjected to a dose of 100 ma. min. The animal recovered promptly, and remained in perfect condition without showing any symptoms, for three weeks. At the end of that time an autopsy was performed. The exposed loop could be identified because of its contraction, hyperemia and smooth appearance. It measured just 2½ in. in length and showed considerable subserous injection of blood-vessels. The external appearance of the loop is shown in Figure 7. When the intestine was opened, the greater portion of the epithelium in the exposed area was found to be absent, and that which remained was in a necrotic condition. The denuded areas were quite smooth, and dark red

in color. The margins of the involved region were very sharply defined.

Figure 8 shows a very low-power view of a longitudinal microscopic section extending from the normal into the abnormal intestine. The abruptness with which the mucosa stops is strikingly shown. The submucosa is considerably thickened, and shows much white-cell infiltration. The muscle bundles in the wall of the intestine show vacuolization, and are therefore also damaged by the exposure. There are no definite changes made out in the blood-vessels.

A large pregnant bulldog was selected for the application of the dose of 150 ma. min. Ten and one-half inches of the small intestine were exposed. The upper end of the uterus lay within the field of exposure. At the end of ten days, the animal appeared to be in excellent condition, and there was a definite erythema over the small portion of skin which was used as an indicator. At the end of two weeks, the animal showed no symptoms whatsoever, but autopsy was decided upon.

The skin area showed a shallow ulceration at that time. On opening the abdomen, the loop could be identified by its smooth appearance and by the blood-vessel injection, as in the previous experiments. It measured 5 in. in length. On opening the intestinal tube, the exposed region was found to possess a smooth red inner surface, over which there was no trace of an epithelial covering. The striking appearance is shown in Figure 10. The decreased diameter of the lumen can be easily made out. There was no tendency toward abortion during the two weeks of observation.

The most puzzling feature of all these experiments was the good condition of the animals, which persisted up to the time of autopsy. The work of Warren and Whipple had led us to believe that *x*-ray damage to the intestinal epithelium would cause death within four days. It was thought wise to repeat the above experiment and keep the animal as long as possible, in order to study the end results. A medium-sized black dog was selected and a dose of 150 ma. min. administered to a loop of small intestine 9¼ in. long. There were no symptoms at the end of two weeks, but at the end of sixteen days the animal refused food and began to lose weight and to go down hill rapidly.

FIG. 9. External appearance of intestinal loop two weeks after receiving a dose of 150 ma. min. Note the skin control just below the incision. The smoothing out of the involved region is the most striking change.

FIG. 10. An opened portion of the loop shown in Figure 9. The complete loss of epithelium and the contraction of the involved area are well shown.

At the end of nineteen days, the dog's condition was so bad that autopsy was decided upon. The findings were practically the same as those described above, for a dose of 150 ma. min. The loop measured 4 in. in length and showed complete desquamation of epithelium. The emaciated condition of the animal is shown in Figure 11, and the appearance of the intestinal loop in Figure 12.

These findings seem to indicate that double the minimum erythema dose is rapidly fatal. It is to be regretted that lack of time prevented our observing the effects of the smaller doses over longer periods. It seems fair to assume that the milder reactions would finally produce a stenosis, even though no toxic symptoms appeared.

These experiments bring out certain points of interest. For instance, it seems evident that it would be impossible to deliver a minimum erythema dose into the abdomen of a dog without injuring the intestine. Unfortunately, the experiments cannot be directly applied to the human body, since there is no way of comparing the sensitiveness of the human intestine with that of the dog. If all the portions of the dog's body possess the same relative degree of sensitiveness to the rays that has been observed in the human body, then these animal experiments seem to prove that no erythema dose can be delivered into the abdomen without producing intestinal damage. They also suggest that a certain degree of damage to the small intestine is compatible with life. Evidenc

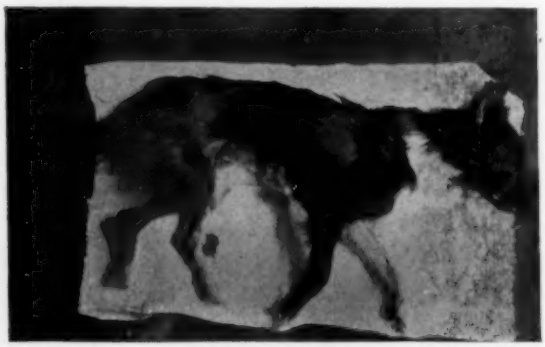


FIG. 11. Great emaciation of animal nineteen days after receiving 150 ma. min. over a single loop of small intestine. This condition resembles the roentgen cachexia observed clinically.

of a more convincing nature can be obtained at the autopsy table. Let us suggest that the intestine be carefully examined, where cases that have received ultra deep therapy over the abdomen come to autopsy. It is not sufficient to study the serous surfaces, since the maximum damage occurs in the mucosa. All the loops in the exposed region should be opened.

The term "roentgen cachexia" has been appearing in the foreign literature for some time. It seems that certain patients become much emaciated after being subjected to heavy doses of *x*-rays as administered in Europe. After studying the emaciation produced in guinea pigs, rabbits and dogs by heavy doses of rays delivered over the abdomen, we have been led to conjecture that possibly the "roentgen cachexia" observed in human beings may have a similar origin. The causes of this cachexia are uncertain. Is it due to a toxemia, to diminished food intake, or to diminished digestive power secondary to the intestinal lesions? Perhaps other factors are involved. Further analytical work is required to answer these questions.

We wish to acknowledge the valuable assistance of Dr. B. F. Hambleton in the operative work and of Dr. G. C. Caldwell in the post-mortem studies incident to the preparation of this paper.

FIG. 12. Opened section of exposed loop of intestine from dog shown in Figure 11. The control skin reaction is seen just below the folded towel. The desquamation of epithelium over the involved area is complete.

SUMMARY

1. The skin of the dog is much more resistant to roentgen rays than is the skin of man.

2. The minimum erythema dose for the dog's skin when applied directly to the dog's intestine produces hyperemia, marked contraction in all directions and destruction and desquamation of the mucosa.

3. Bloody diarrhea, ulceration, perforation and stenoses occurring in patients subjected to ultra deep therapy for abdominal tumors may be due to direct intestinal injury.

4. Roentgen cachexia is possibly due to the same cause.

5. Intestinal damage in dogs, resulting from direct radiation, does not always produce an early death.

BIBLIOGRAPHY

1. Denis, W., and Martin, C. L. *Am. J. M. Sc.*, Oct., 1920, clx, No. 4, 555.
2. Warren, S. L. and Whipple, G. H. *J. Exper. M.*, Feb., 1922, xxxv, No. 2, 187.
3. Dragstedt, L. R., Moorhead, James J., and Burcky, F. W. *J. Exper. M.*, xxv, 421–439.
4. Béclère, A. *Presse méd.*, Nov. 23, 1921.
5. Fischer, B. *Strablentherapie*, Feb. 1, 1922, xiii, 333.
6. Kroenig and Friedrich. Radiation Therapy, 1922,
7. Martin, Charles L. Am. J. Roentgenol., vi, No. 4. 180–187.

IMPORTANT POINTS IN THE TECHNIQUE OF ROENTGENOLOGICAL EXAMINATIONS OF THE URINARY TRACT*

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During the past twenty years, the development of new methods and instruments has led to an increasing accuracy in the diagnosis of diseases of the genitourinary tract. The greatest single achievement was perhaps the invention of the cystoscope, by means of which pathological conditions of the bladder can be visualized. Catheterization of the ureters followed the introduction of the cystoscope, and in 1906, Volker and Von Lichtenberg reported the first successful injection of an opaque substance into the ureter and kidney pelvis, thus making possible the development of one of the most valuable diagnostic aids in identifying pathological conditions of the genitourinary tract.

The next great advance we point to with pride because it was developed by our president. In 1919, Dr. Stewart and Dr. Stein perfected the technique and introduced pneumoperitoneal examinations in this country. This was an important advance. By this measure, accurate visualization of the kidneys may usually be made, and their size, shape and position determined. It is also of the utmost value in diagnosing tumor of the kidney, particularly when we are in doubt as to the origin of a tumor mass in the region of the kidney.

Dr. Carelli of Buenos Aires further developed the technique of gas inflation, and by his method of perirenal injection the kidney may be well visualized. This is of particular value in cases in which we wish to show the upper pole of the kidney and the suprarenal glands.

When a case is referred to the roentgenological laboratory for examination, diagnostic plates should be made of the entire genitourinary tract. We often have patients referred to us for confirmation of a previous diagnosis of calculus in one or the other ureter. Often such a patient has with him roentgenograms showing the suspected shadow in the ureteral area. These may be of good diagnostic quality, and we may make another of this same area which corresponds to those brought by the patient (Fig. 1). Nevertheless, these plates do not give sufficient data on which to base a diagnosis.

A complete examination of the entire genitourinary tract should be made in every case. Often another calculus may be found in the kidney on the same side as the ureteral calculus (Fig. 2, *a* and *b*); or one may be present on the opposite side. Such information is of the utmost importance to the surgeon before an operative procedure is undertaken. The presence,

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size and shape of both kidneys should be determined in every case which presents symptoms indicating a possible pathological condition in the genitourinary tract. The outline of the liver should be definitely determined, as an enlarged liver or an elongation of a single lobe may easily be mistaken for a movable kidney (Fig. 3).

A careful and complete clinical history, with a microscopical examination of the urine should be made in every case, as this will often guide us to the proper technical procedure whereby we may reach a correct diagnosis. In the absence of calculus, a history of pain, together with its character and duration, may indicate a floating kidney, a tumor, or an intermittent hydronephrosis, which is often overlooked, and the patient submitted to operation for chronic appendicitis or a gall-bladder lesion, without resultant relief. Not only can hydronephrosis be definitely diagnosed by pyelography, but often the cause also can be determined, and therefore failure to diagnose or eliminate this condition demonstrates a poor technique on the part of the roentgenologist.

Bacilluria and the type of bacteria present in the urine, or hematuria, or a combination of these clinical findings are often the factors which determine what technique should be followed in further efforts to determine the nature of the pathological condition.

All these examinations of the kidney, the ureter and the bladder are best carried out in collaboration with a competent urologist. The point which I wish to emphasize is the importance of a careful analysis of the clinical and laboratory findings as a guide to our technical procedure; a report of negative findings from the roentgenologist often gives the referring physician or surgeon a wrong impression, with the result that he may make no further investigation of the case. It is, therefore, evident that the roentgenologist should eliminate the possibility of any pathological condition which is demonstrable by a roentgenological examination, and that, in each case, he select a suitable technique to accomplish this purpose.

FIG. 1. Calculi in the left ureter.

FIG. 2*a*. Calculi in the ureter and in the kidney on the same side.

Our present technique for the first examination of the genitourinary tract is as follows: The patient is examined without any previous preparation. If a suspicious shadow is found at this first examination, the patient is given a thorough preparation by catharsis followed by an enema, and the second examination is made. Castor oil is not used as a cathartic, as it produces considerable gas in the intestines, which usually interferes with the visualization of the kidneys.

If no shadow is found in the second examination, we can conclude that the one seen at the first examination was an enterolith or some opaque substance in the intestinal tract.

All kidney examinations are made on 14 × 17 duplitized films with double screens, and a Potter-Bucky diaphragm

55 kv. 20 ma. at a distance of 25 in., the time of exposure being governed by the size of the patient. Deep compression by means of an inflated rubber bag is always used, and the tube remains over the center of the diaphragm without tilting. Two films are used; on one, the crest of the ilium is placed 1 in. above the center of the film (Fig. 4), thus giving a complete view of the bladder and ureters; on the other, the crest of the ilium is placed 1 in. below the center of the film thus showing both kidneys and both ureters (Fig. 5). This same technique is used in all kidney examinations.

We are trying a curved cassette which brings the kidney close to the film, and also brings the portion of the film which is under the kidney closer to the tube than that portion which is under the spine, thus giving the kidney relatively more exposure than the spine. We are experimenting also with a new type of film coating which approaches a portrait emulsion and gives details of the soft shadows which are brought out still more by developing the films in solutions which contain a relatively small proportion of bromides.

We wish here to express our appreciation of Dr. Potter's perfection of the Bucky diaphragm, which has made possible the development of this technique.

If a shadow is seen in the kidney area, which we believe to be a calculus, it should be determined whether it lies in the kidney pelvis or in the cortical substance of the kidney. This may necessitate the making of a pyelogram. If the calculus is outside of the kidney pelvis, it will be easily seen; if within the kidney pelvis, it will probably be obscured by the opaque injection. This information is important to the surgeon, as he will be guided in his operative procedure by approaching the kidney at the most advantageous point for removal of the calculus.

A suspicious shadow in the ureteral area of either side should be checked by catheterization of the ureters with an opaque catheter, and films made at two different angles, to determine the proximity of the shadow to the catheter which represents the lumen of the ureter.

I wish to emphasize the importance of the technique in this particular type of case. Usually, if the shadow is found to be in contact with the catheter in each of

FIG. 2*b*. Calculi in the left kidney and calculus in the right kidney.

FIG. 3. Elongated liver lobe which, on palpation, feels like a displaced kidney.

FIG. 4. Position of the film with relation to the crests of the ilia for examination of the bladder and ureter.

FIG. 5. Position of the film with relation to the crests of the ilia for examination of both kidneys and ureters —polycystic kidneys.

FIG. 6a. Suspicious shadow in the lower left ureter.

FIG. 6b. Catheter in place showing the suspicious shadow apparently outside of the ureter. Same case as shown in Figure 6a.

two positions, we feel reasonably sure that the presence of a ureteral stone is indicated. In the case of a small calcified gland below the ureter, one anterior posterior plate of the catheterized ureter may show a shadow directly in contact with the catheter. Another exposure giving a marked oblique or lateral view, however, may disclose a considerable space intervening between the shadow and the them (Fig. 6, *a* and *b*). With a problem of this kind, a ureterogram should be made which will give the exact size of the lumen of the ureter, with the extent of dilatation, and usually the point of constriction (Fig. 7, *a* and *b*). This method is much more accurate than the waxed-tip catheter, which may be introduced into the dilated ureter, and at no time come into contact with the calculus.

FIG. 7*a*. Injected ureter showing large hydro-ureter. Ureter contains both catheter and calculus. Same case as shown in Figure 6*a*.

FIG. 7*b*. Injected ureter and kidney, shown in Figure 6*a*, after removal.

catheter, a finding which will usually rule out a calculus. But even a second plate is not sufficient in all cases. Frequently, particularly in the case of a large calculus, the ureter becomes dilated from over-distention due to obstruction. This distention may be enormous, so that the ureter may measure more than an inch in diameter. With this type of case, both the catheter and calculus may be in the ureter, with a considerable distance between

When examination of the films shows no evidence of calculus, we should report that the roentgenological findings are negative to calculus; but to this report we should add the statement that in a small per cent of cases, calculi may be present in the ureter or kidney which will not be seen on the roentgenograms. We believe that in some cases, this lack of visibility is due to the small size of the calculus, and in other instances, to their chemical com-

position. A review of a recent series of 54 cases which were operated upon by Dr. W. E. Lower shows that in one case—or 1.8 per cent—the calculus did not show on the roentgenogram.

FIG. 8*a*. Hydronephrosis with kinked ureter.

The visibility, size, shape and position of the kidneys should be included in every report, together with spinal lesions or any other pathological condition of adjacent organs which may in any way account for the patient's symptoms.

If all the findings are negative, the clinical symptoms and history should be carefully analysed in consultation with the urologist, and a further study of the case should be made.

Catheterization of the ureter on the side on which the patient complains of pain, and injection of the kidney, pelvis and ureter with sodium iodide solution to determine the possibility of hydronephrosis (Fig. 8, *a*, *b* and *c*), hydro-ureter (Fig. 9), deformed kidney pelvis (Fig. 10, *a* and *b*), obstruction or kinks in the ureter (Fig. 11, *a* and *b*), should be done in cases with suggestive clinical symptoms. We have found a 20 per cent solution of sodium iodide to be the most satisfactory solution for pyelography. In our clinic, all this work is done in the urological section under the supervision of Dr. W. E. Lower. The injections are made by the syringe method, and only one side is injected at a single examination.

Films are made first after the passage of the catheter; then, after injection of the

FIG. 8*b*. Hydronephrosis.

FIG. 8*c*. Hydronephrosis.

kidney pelvis or ureter, another film is made with the catheter still in place. The

FIG. 9. Hydro-ureter; obstruction in ureter at pelvic brim.

catheter is then removed and the patient placed in an upright position and a third film is made. This last position gives a splendid outline of the kidney pelvis and ureter and allows a kinked ureter to assume a position corresponding to that which is present when the patient has an attack.

Many cases, however, have a dilated ureter, or a ureter devoid of its normal musculature; and when the patient is placed in the upright position, the solution immediately flows into the bladder, so that the film will give us no information, but rather appears normal. In such a case, the film with the catheter in place and the patient in the horizontal position will be the one that will be of diagnostic value.

We found that it was necessary to have a practical table on which to carry out this technique (Figs. 12 and 13). We used, as a nucleus, a Young cystoscopic table, to which a tube stand was attached. The top of the table was removed and a Potter-Bucky diaphragm built into the table, the whole being covered by a sheet of aluminum. A 30 ma. radiator type tube is used with a small transformer on the wall. This will deliver a 5 in. spark gap at 20 ma., which is ample for all cases. Deep compression is made by an inflated rubber

FIG. 10*a*. Deformed kidney pelvis in a case of tumor of the kidney.

FIG. 10*b*. Deformed kidney pelvis in a case of pyonephrosis.

FIG. 11*a*. Kinked ureter with obstruction by calculus at the lower end. The film was made with the patient in the upright position.

FIG. 11*b*. Kinked ureter.

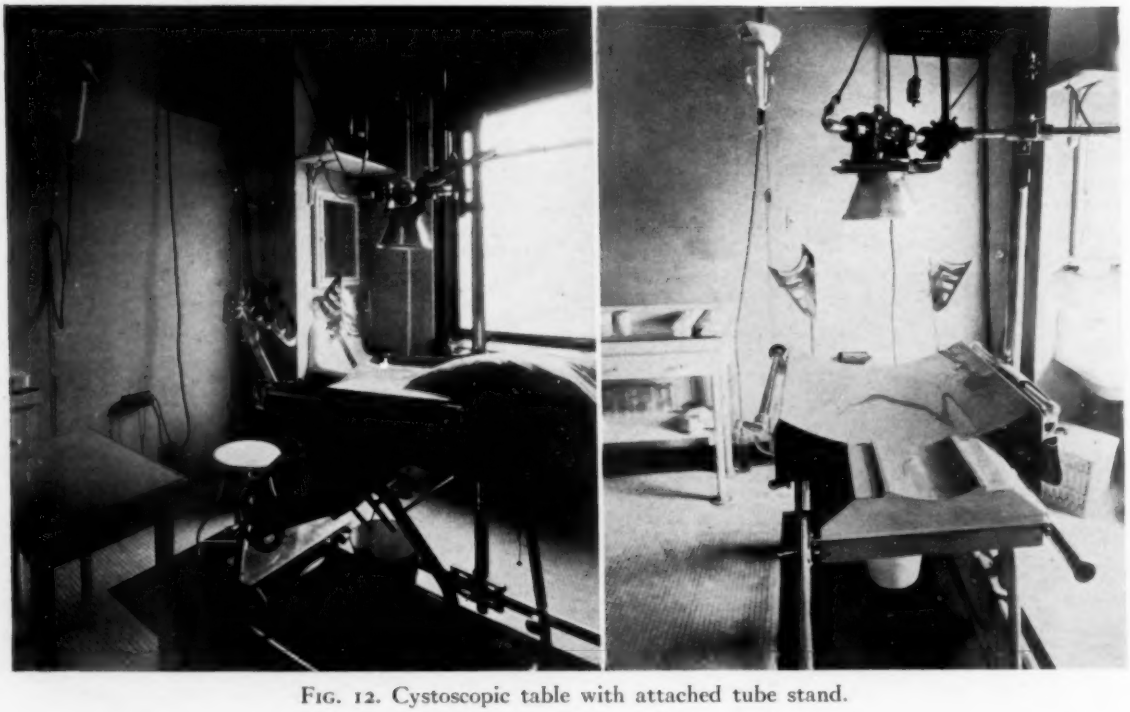


FIG. 12. Cystoscopic table with attached tube stand.

bag and web belt. This table is in the urological section, and is used daily for ordinary cystoscopic examinations.

SUMMARY

The important points in the technique of roentgenological examinations of the urinary tract which I have endeavored to point out are the following:

1. That the entire urinary tract should be examined in all cases.

2. That catheterization of the ureters with an opaque catheter will not determine the character or position of all suspicious shadows in the ureteral area, but further study should be made by means of ureterograms.

3. That in pyelograms made in the upright position, there is the possibility that the solution may pass quickly through a patulous ureter into the bladder; hence, an examination should be made in the horizontal position also.

4. That a convenient and practical table with a Potter-Bucky diaphragm is essential.

DISCUSSION

DR. JACHES. I, for one, am very much indebted to Dr. Nichols for having presented this paper. It seems that discussions on deep therapy, diagnoses of chest conditions, and possibly, also, diagnoses of gastrointestinal tract conditions have occupied us so much that we have forgotten that there is a genitourinary tract. I have seen very few papers presented on the subject lately. Dr. Nichols' paper has covered the subject so fully that I have little to add, and will limit myself to asking questions.

FIG. 13. Cystoscopic table showing its use with patient in two positions.

I want to say that a point well taken is the statement at the close of his report that the roentgenological examination does not present evidence of calculus, but what must be borne in mind is that a small percentage of them cannot be demonstrated by the *x*-ray.

By careful urological checkings we have been able to demonstrate, at the Mt. Sinai Hospital,

that in the ureter the percentage of error is something like 11 or 12. The Johns Hopkins Hospital percentage has once been reported as high as 25. In bladder cases the percentage is much higher. Fortunately, in bladder cases, the cystoscope is available for determining the presence of calculus.

I did not hear Dr. Nichols speak of some of the sources of error. Lately there have come to my attention two cases. In one, a very prominent roentgenologist made a diagnosis of the presence of calculus which turned out to be a wart on the back of the patient. Fortunately, this was checked up before operation. On the other hand, it sometimes happens that the patient has a wart just in the location of the calculus, and you might be misled into the belief that the shadow which was present was not that of a calculus, but due to that particular wart.

Some years ago, a patient presented himself to me who had a scab in the region of the kidney, due to the breaking of a hot-water bag. He had smeared it very carefully with zinc oxide, and attempts to remove it led to much bleeding. The patient was submitted to the *x*-ray, and I found a shadow in the region of the right kidney pelvis, corresponding in size and shape to that scab. I reported that a shadow was present, but in view of the scab on the back, I would prefer to re-examine the patient after it had come off. For some reason or other, the patient was never *x*-rayed again. Finally the surgeon had the courage to operate, and found a calculus which consisted mainly of uric acid. Now I am not so certain whether it was the calculus or the scab which was shown on the roentgenogram.

There are a few questions I would like to ask. I did not quite hear Dr. Nichols' explanation for making his first examination without preparation of the patient. I find that whenever the patient is not prepared, the whole examination is futile—at least I have not had the courage to make any diagnosis on roentgenograms showing intestinal gas.

Next question: How much does he gain in taking his ureterograms or pyelograms in the upright position, considering the trouble and inconvenience to the patient? In the several attempts we have made, we might have been able to show a kink a little more distinctly, but, nevertheless, a kink in the ureter shows up in the horizontal position.

Dr. Nichols has also shown some films which were taken with the patient in the prone position. This is a very good point. It is really necessary to make roentgenograms in that particular position in every male patient over the age of forty. You will often discover a small calculus just above the symphysis, particularly if you incline your tube so as to project the rays upward toward the umbilicus; in many cases I have found small calculi in the prostate which were hidden by the symphysis in the other view.

Dr. Edmonson. I think it is quite essential where you see any evidence at all of curvature in the ureter, that a roentgenogram be taken in the erect position. I have had a number of cases of curves, especially in the region approximating the kidney, where the erect posture produced, or converted them into, acute angulations.

Dr. Bowen. Dr. Nichols' paper is, in the first place, a sort of monument of team work. I do not think we have ever seen any work of this quality which was not the product of good team work.

The use of this type table has interested me considerably. We do our ureteral work in the Pennsylvania Hospital by having the patient catheterized at a considerable distance from the *x*-ray room and then carted down, with more or less unfortunate results.

I was particularly interested in what Dr. Nichols said about reports. I think we ought to stereotype consistently our expressions, especially in dealing with the men we are usually working with. Then we ought not to forget, when we are reporting to strangers, to be sure we are talking their language. We get into the habit of making our reports brief in a way that our own groups well understand, but the same words may be misunderstood by a stranger; especially if we make a study which we know is incomplete, we must not fail to express that fact plainly in closing the report. The mere omission of a few words may make the report misunderstood.

I was also particularly interested in the positions Dr. Nichols uses. We use stereoscopic plates and they seem to answer every purpose. This gives two positions, but they are more alike than his. I was interested to see the uniform posture results Dr. Nichols is getting.

One question I would like to ask with regard to ureteral cases that were followed by the opaque injection. I would like to know whether this is done at the time of the first examination; whether the plate is developed hurriedly and the examination made then, or at a second examination. In case of a small ureteral stone I believe it is, possibly, advisable to wait several days, because very frequently these small stones do pass after the ureteral catheterization, without any further trouble or manipulation.

Dr. Imboden. For many years we have used the stereoscopic method in examinations of the urinary tract. Occasionally a shadow was found in the kidney region which was difficult to differentiate from bodies other than those connected with the urinary tract. We have found that by making exposures on both inspiration and expiration some of our difficulties have been overcome. For instance, if there is a stone in the kidney, it retains its same relative position to the kidney on films that are made on full expiration and inspiration, but if the shadow is due to calcified gland its relationship to the kidney is changed, but not that to the spinal column. This examination does not pertain to the ureters.

Dr. Stewart. Would Dr. Nichols give us his differential points on the diagnosis of cystic kidneys by means of the pyelogram? I have always hesitated in attempting to designate the kind of pathology present from the roentgenographic examination alone. There are some tuberculous kidneys with a great deal of deformity and contraction and the presence of abscess cavities which can be recognized by pyelography. Cystic kidneys, however, do not give any characteristic shadow; consequently they are hard to recognize.

A number of years ago I made some original investigations and found that there was a normal excursion to the kidney, between full expiration and inspiration, of about 2½ to 2 in. and that one could easily demonstrate that the kidney descended in the erect position.

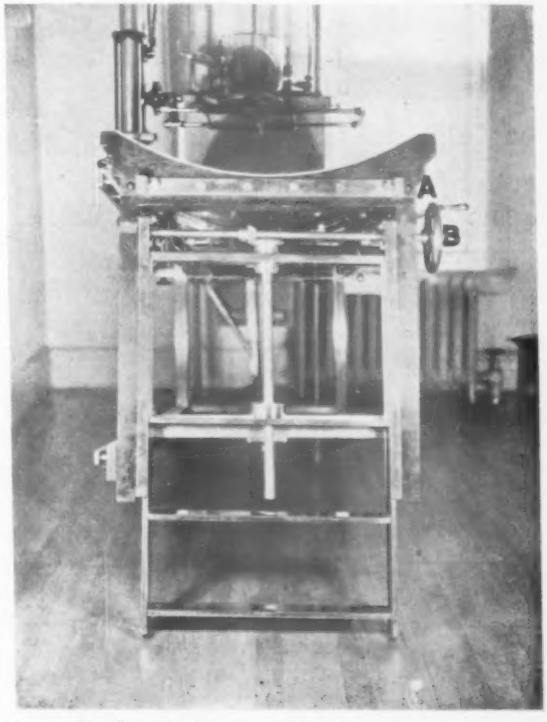
My experience does not tally with that of Dr. Jaches. In a number of cases we were able to demonstrate a kink to the ureter in the erect position, which, in the prone, did not show nearly as well.

Dr. Hickey. I would like to ask Dr. Nichols what he experienced as the proper method of preparing. I understood him to say not to use castor-oil. If he does not use castor-oil, what does he prefer?

I had a patient who had a large-sized stone in the kidney. I picked it up on fluoroscopic examination of the gastrointestinal tract, and I thought that would be a good chance to measure the excursion of the kidney. So I spent some time in measuring the excursion, and I found this shadow would move ½ in. during ordinary respiration, and on full inspiration would move 1½ in. This was quite a striking observation to me at the time, because I had not thought the kidney descended so far with the average patient in the course of respiration.

Dr. LeWald. I am interested in Dr. Nichols' table. Recently we have made all our examinations of the urinary tract on a Potter-Bucky diaphragm table. In order to give a tilt to the table we have added an elevating mechanism which I will illustrate.

I regard tilting of the patient as important in making pyelograms, since in some cases of partial double ureters we may in this way cause



Potter-Bucky diaphragm table with elevating attachment for cystoscopic use. Also can be used for mastoid and sinus work. (*A*) Holder for knee support; (*B*) elevating wheel.

the opaque solution to run into the bifid ureter, if the patient is in a slightly inverted position with the head lowered. Of course, the reclining or vertical position is equally important.

Dr. Childs. In reference to this point that Dr. Hickey mentions about the change of position of the kidney in respiration, I will state that in conjunction with Dr. Spitzer of Denver, a series of cases were examined to ascertain the normal shape of the pelvis and calices of the kidney, and in these observations plates were made in the prone and erect posture, both on inspiration and expiration. We examined 29 cases—cases that by clinical evidence as well as by the radiological findings appeared normal. We found in these that the difference in excursion from full expiration to full inspiration varied from ¾ to 1½ in.

There is one point I desire to mention in the

discussion of Dr. Nichols' paper, which paper I consider one of the best I have heard on this subject: that is, if an operation on a kidney in which a calculus has been definitely located, is to be postponed for two or three days, a subsequent examination, just prior to the operation, should be made. I recall one case in which two stones were demonstrated in the right kidney, both in the upper calices. A few days later, these stones were demonstrated in the pelvis; still a few days later, and just prior to the operation, one was demonstrated in the pelvis and one in the lower calix, and in the latter locations they were readily found by the surgeon.

Dr. Nichols (closing discussion). I am very grateful for this general discussion. I tried to bring these points out, but it is difficult to cover a large field without omitting some things of importance.

I was very glad to hear Dr. Jaches mention the point in reference to warts and foreign bodies on the surface which may give shadows simulating stones in the ureter or kidneys.

In regard to the question of examination without preparation: I would not say that is the best method to use, but that is the method we use from pure necessity. Most of our patients present themselves from quite some distance, and are perhaps examined that day and go right home. For this reason, we commenced it as a routine. It is best to prepare the patient beforehand, if you can, but we cannot do that. If we find a suspicious shadow, we have the patient return.

In regard to the use of castor-oil: It has been my experience that castor-oil produces an enormous amount of gas in the gastrointestinal tract. We prefer saline cathartic.

The question of upright position for making pyelograms has been fairly well answered. The consensus of opinion is that with this method, one can bring out kinked ureters that cannot be found with the catheter in position.

In regard to Dr. Bowen's question as to injection: We usually do this at the same time that we do the examination, without developing the plate. If there are clinical symptoms, we simply do the injection at the same time while the patient is on the table. It takes only a few minutes.

In regard to the point about Trendelenburg's position: We think that with the method we use of injecting the kidney and ureter, it is not necessary to put the patient in this position. We use the syringe method and inject until the patient feels a distinct pain inside. I think, if one is using a lesser amount of solution, one can, by the gravity method, bring out points in the pelvis and ureter that one cannot get by taking the picture in the horizontal position.

With reference to Dr. Stewart's comment on the polycystic kidney: As I stated, that case has not been operated upon, and I may be wrong. The patient is a man, perfectly well, weighing nearly 300 lbs. He complained of some disturbance in the back. Urine showed nothing. We could see, well outlined, cystic areas all over these kidneys—upper pole and lower on both sides. We concluded by the process of elimination, that it was a polycystic kidney. However, we may be in error.

Dr. Childs' point in regard to re-examining cases when operation is deferred, is well taken. It has been brought home to all of us that these stones have a peculiarity of changing position, particularly where there has been dilatation of the ureter and pelvis. If the patient is not operated upon on the day of examination, he should be examined at least very shortly before operative procedure is undertaken.

Dr. Bowen (after Dr. Nichols' closing). I want to say a word with regard to preparation. I have a very definite opinion that a properly given enema is the proper preparation. I want to agree with Dr. Nichols and go a little further by saying that I would rather not have the patient prepared at all than to have him prepared with castor-oil. Fasting and repeated enemas should be given until one is positive that the entire colon has been flushed. We then shall not have gas bubbles, and will have the patient properly prepared.

NEW LIGHT ON GASTRIC PERISTALSIS*

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SAN FRANCISCO, CALIFORNIA

ANY roentgenologist who has not degenerated into a mere technician—a skilful hunter after filling defects—must often wish he could interpret more clearly the various forms of gastric peristalsis which he sees on the screen. He knows that they are atypical and perhaps abnormal, but the waves pass so rapidly, and so many things happen in different places at one time, that he cannot be sure of what he has seen. Even if he could be sure, he would not be able to tell the attending physician what it was all about, and where to look for the primary cause of the disturbance. Similarly, years ago, when I was a student in college, a heart, no matter how badly it was diseased, was uninteresting unless a big murmur could be made out. Today we are far more interested in defects of impulse origination and conduction than we are in murmurs. Volumes have been written on peculiarities of the cardiac impulse which were unheard of twenty years ago.

Now why has there been such a tremendous advance in our knowledge of the movements of the heart, and so little in our knowledge of the movements of the stomach? The answer is that the technique for studying the gastric movements is much the same today as it was fifty years ago, when the new methods of studying the heart began to appear. About 1870, men stopped *looking* at the heart, and began to record simultaneously the movements of auricles and ventricles on the same smoked drum. Later, they recorded the electrograms from two parts of the heart at the same time. The gastroenterologists have gone on simply looking at the stomach. To be sure, valuable work has been done with serial roentgenography, but the technique has been difficult and expensive; and, so far as I know, no professional physiologist has used it.

One of the principal reasons for this neglect of gastric physiology is that special types of apparatus have had to be designed to help in overcoming the technical difficulties which stand in the way. Imagine attempting to record the delicate movements of the cardiac end of an animal's stomach, situated as it is high up under a diaphragm which never ceases in its upward and downward excursions. That is bad enough, but just as an experiment is going well, along comes, perhaps, a deep sigh which tears off and disarranges the apparatus. It is not work for any one inclined to impatience or indulgence in profanity. Some may ask: Why not use balloons? The answer is that they slip about, and it is too difficult to say what they are recording.

DEVELOPMENT OF APPARATUS

In 1914, I devised a simple little enterograph, with which I was able to get records from two or three parts of the stomach and six or seven parts of the bowel at one time.[1] The animals were anesthetized and their abdomens opened in a tank of warm Locke's solution. During the last two years I have been developing apparatus which enables me to get electrogastrograms from six parts of the stomach and intestine at one time. I am also getting simultaneous electrograms and mechanograms from two segments of the stomach or bowel. Human electrogastrograms have been obtained with electrodes applied to the abdominal wall, and also with electrodes passed into the stomach.[2] I will not go into the question of technique at this time, partly because some of it has been published elsewhere,[3] but mainly because the apparatus is daily being changed and improved upon. Naturally, in the early stages of such a study, the interpretation of the records is difficult, and more new puzzles are found than answers to the original ones.

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Cal., September 12–16, 1922.

WHAT HAVE WE LEARNED WITH THE NEW TECHNIQUE?

In the first place, it is clear that when the galvanometer is so arranged that an upward swing on the record indicates a negativity of the orad electrode, the electrical records look very much like the mechanical ones obtained by fastening a heart lever to the segment of stomach or bowel between the two electrodes. The gradient of rhythmicity from duodenum to colon[4] is again shown very clearly.

THE GASTRIC PACEMAKER

Both the electrical and the mechanical records show that many of the waves which seem to begin in the lower third of the stomach have really come as shallow ripples from the region of the cardia. There is an area on the lesser curvature next to the esophagus which appears to be the usual pacemaker, but it has not yet been localized with accuracy. It is clear from some of the records that the pacemaker can shift

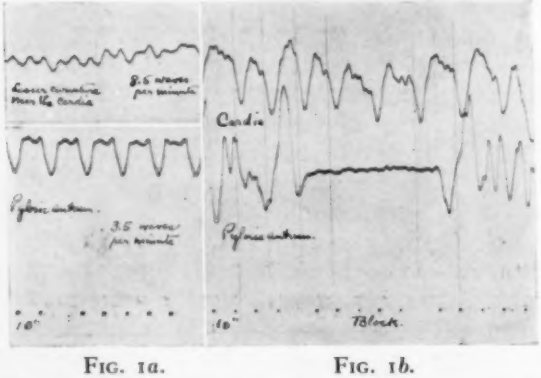

FIG. 1a. FIG. 1b.

FIG. 1a. Electrogastrograms from the lesser curvature near the cardia and the pyloric antrum of a cat. In all these records an upward swing denotes negativity of the orad electrode. The time record shows ten-second intervals. This record shows a dissociation between the activities of the fundus and the antrum.

FIG. 1b. Electrograms from the cardiac and pyloric regions of a cat, showing blockage of four waves.

about, much as it does in the heart, and there are strong indications also of dissociation between the activities of the fundus and the pars pylorica.

STOMACH BLOCK

Just as in the heart, so in the stomach, we find blocks of short or long duration. We have found them most frequently at the junction between the body of the stomach and the pyloric antrum, but they can occur elsewhere, as at the cardia. Many of the records show also a phenomenon frequently observed on the screen, that is, the appearance of contractions which do not spread over the stomach, but spring up and die away in the same place.

DISSOCIATION BETWEEN THE FUNDUS AND THE PARS PYLORICA

I have long looked upon the stomach as two organs thrown into one; a crop and a

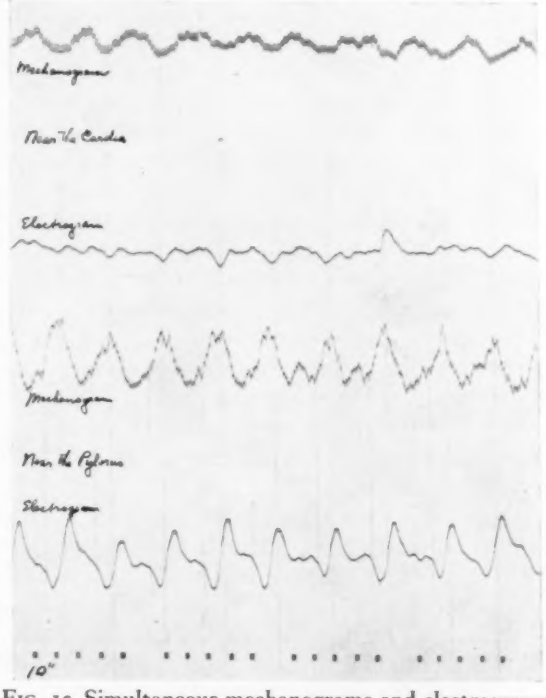

FIG. 1c. Simultaneous mechanograms and electrograms from two parts of the stomach of a rabbit.

gizzard; a hopper and a mill; an acid producer and a mixing chamber; but I was not prepared to find so much dissociation of rhythmicity as appears on some of the records. In some cases, the cardiac region seems to contract three or four times to the antrum's once; but there is seldom, if ever, any constant relation between the two rhythms; that is, one minute the ratio may be 8.5 to 3.4, and a little later it will be 9.3 to 2.6.

GASTRIC SYSTOLE

Years ago, Cole noticed on his serial plates contractions of the stomach as a

whole, which he called systoles. His fellow roentgenologists and the physiologists never seemed to take much stock in this observation, because they apparently could not repeat it for themselves; but I find a systolic type of contraction so frequently in my records, that I believe Cole was right. This brings out a point which I wish to make, namely, that we can easily miss things on the fluorescent screen, even when our attention has been called to them. How much more easily can we miss them if our attention has never been called to them. These systoles may have a considerable importance in gastroenterology, because

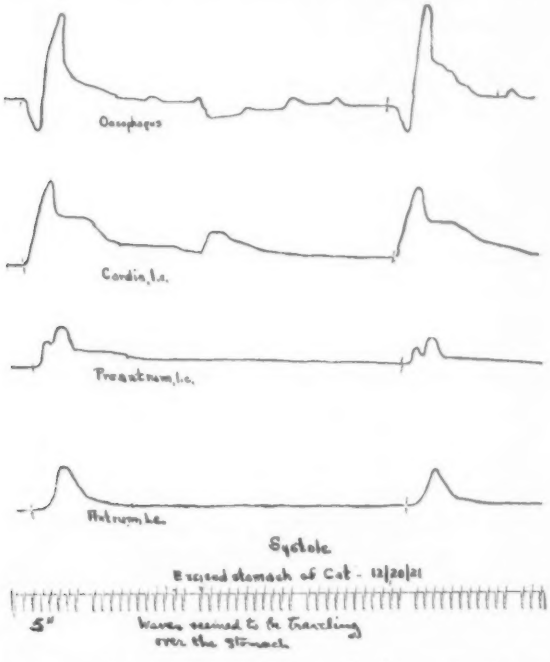

FIG. 2. Mechanical records from the lower esophagus, the cardia, preantrum and antrum of the excised stomach of a cat. It shows systoles and a lack of conduction at times from the esophagus to the cardia and from the cardia to the preantrum. The time record represents five-second intervals.

the records suggest that they can have much to do with helping or hindering the escape of food from the stomach.

Another peculiar feature of these systoles is that they seem sometimes to be associated with peristaltic waves; that is, while a wave is slowly traveling from the cardia to the pylorus, another contraction which does not give rise to any peristaltic wave appears at the cardia, and is followed almost instantly by a contraction in the antrum. Sometimes it seems as if the antral contraction were in turn the origin of contractions in the middle of the stomach. For this reason, my assistant and I have come to speak of these easily recognized series of coupled contractions as "shuttle rhythm."

AUTOMATICITY OF THE PYLORIC ANTRUM

There are many signs in the records that the muscle in the pyloric antrum tends to

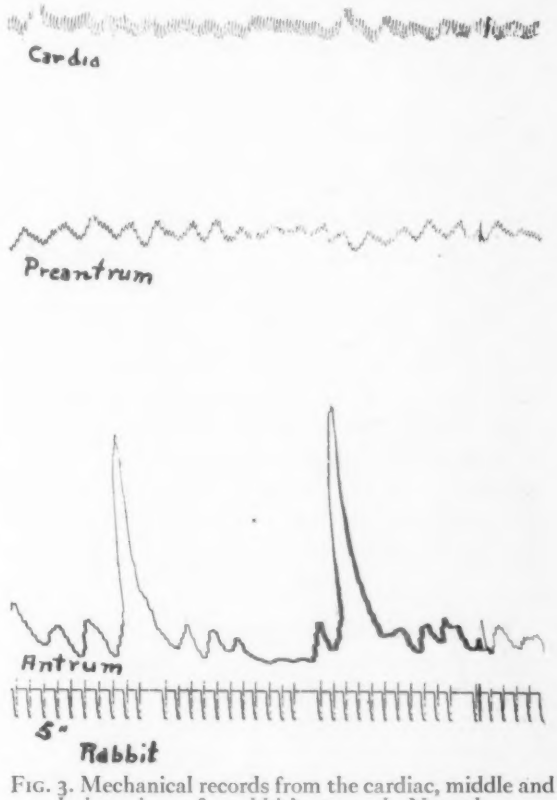

FIG. 3. Mechanical records from the cardiac, middle and pyloric regions of a rabbit's stomach. Note the occasional large contractions of the pyloric antrum.

contract at its own rate, which is about three times a minute.[5] Even when it is dominated by rhythmic stimuli coming down from the cardia, it will contract powerfully from time to time much as the ventricle of the heart does when it gives rise to extra-systoles. The frequency with which these large waves appear may have something to do with the rate of gastric emptying, and they may also produce pain in the presence of ulceration. Sometimes every third or fourth contraction on the record is twice as high as the others; and

rarely, every other antral wave is two or three times as large as its fellows, so that the record makes one think of pulsus alternans.

TWO OR THREE TYPES OF CONTRACTION AT ONE TIME

It is a remarkable fact that one point on the gastric wall seems to be able to respond to several rhythmic influences at one time. That is, the muscle, let us say, in the fundus, will contract at its own inherent rate of twelve times a minute.[5] At the same time, there may be slow tonus waves once every one or two minutes; and more rapid peristaltic waves once every twenty seconds. Conditions seem to be very similar to those in the bowel where there are the rapid segmenting movements, the occasional peristaltic rushes, and the large tonus changes which I have recently demonstrated. It will interest roentgenologists to know that Palugyay,[6] who screened the stomachs of several men and women while they were in the Trendelenburg position, observed frequent small waves in the fundus: waves different from those in the antrum. Forssell has made similar observations.

RELATION BETWEEN GASTRIC AND DUODENAL PERISTALSIS

Our records show that the tonus waves in the duodenum can be captured by the gastric rhythm and made to follow it for considerable periods of time; i.e., either simultaneously with, or shortly after, the arrival of a gastric wave at the pyloric line, there is a strong tonus contraction in the duodenum. This observation may throw some light on the mode of development of the pain in duodenal ulcer, because we now have every reason to believe that hunger contractions in the stomach will produce similar contractions in the duodenum. Wheelon and Thomas[7] have demonstrated this mechanism with the help of a very ingenious device.

It is interesting also to note that the peristaltic rushes which carry the food down the bowel almost always have their origin in one of these tone changes in the duodenal cap.

CONCLUSIONS

It seems clear, then, that the new methods have promise, and that they have already shown us a number of things which could not be detected by the unaided eye. Naturally, a beginning has barely been made; and much work will have to be done before we know just what relations these findings on animals have to the physiology and pathology of the gastric movements in man. The fact, however, that almost everything which has been discovered about the hearts of animals has had an important bearing on either the physiology or pathology of the heart in man, makes me feel hopeful for the future of this work on the stomach and bowel. I am not so sanguine about the future of practical human electrogastrography; but once the basic principles have been worked out, there is no telling what may be done, especially with the help of the amplifying electron tube which is now revolutionizing wireless telegraphy.

It seems to me that the main hope for the new methods is that they will enable us to recognize and evaluate symptom complexes in the history and on the screen—complexes corresponding to those which are now recognized so easily by the heart specialist, even without the help of his polygraph and his string galvanometer. The important point which I wish to emphasize is that he could not be making these diagnoses at all if he had not been working for years with his instruments of precision.

SUMMARY

Gastric physiology is far behind cardiac physiology today, because it has remained very largely in the crude stage of dependence on unaided visual observation.

Methods are now being devised for obtaining multiple and simultaneous mechanical and electrical records of the activities of the stomach and bowel.

A few records have been obtained of the human electrogastrogram. The electrograms from the digestive tract look very much like the corresponding mechanogram.

New evidence has been obtained as to the location and behavior of the gastric

pacemaker. Stomach blocks and dissociations have been observed. Cole's discovery of gastric systoles has been confirmed.

Several peculiar types of peristalsis are described, and some contractions are shown which might perhaps be called, by analogy, pyloric extra-systoles.

Two or three different types of contraction can take place simultaneously in one segment of the stomach much as they do in one segment of bowel.

There is a close relation between the activities of the pyloric end of the stomach and the duodenum.

It is hoped that the new studies will eventually help the physician and the roentgenologist to recognize and interpret symptom-complexes, much as the polygraph and the string galvanometer have helped the heart specialist to recognize auricular fibrillation or heart block from the history, or from the feel of the pulse.

BIBLIOGRAPHY

1. Alvarez, W. C. *Am. J. Physiol.*, 1915, xxxvii, 267.
2. Alvarez, W. C. *J. Am. M. Assn.*, 1922, lxxviii, 1116.
3. Alvarez and Mahoney. *Am. J. Physiol.*, 1922, lviii, 476.
4. Alvarez, W. C. The Mechanics of the Digestive Tract. New York, 1922.
5. Alvarez, W. C. *Am. J. Physiol.*, 1916, xl, 585.
6. Palugyay. *Arch. f. d. ges. Physiol.*, 1921, clxxxvii, 232.
7. Wheelon and Thomas. *Am. J. Physiol.*, 1921, liv, 460; *J. Lab. and Clin. M.*, 1920, vi, 131.

THE BONE LESIONS OF SMALLPOX WITH REPORT OF CASES*

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BECAUSE of the small amount of literature on the subject, and the lack of anything in the textbooks, I wish to present these cases, that we may be more on the lookout for the conditions.

In regard to the bone lesions of smallpox, I will quote Musgrave and Sison,[1] who report the following distribution of lesions: "Any of the bones and joints of the body may be affected. However, the long bones and their articulations are more frequently affected than other bones and joints. In the order of frequency the following locations of the lesions may be noted:

"1. The bones and joints of the upper extremity.

"2. The bones and joints of the lower extremity.

"3. The bones and joints of other parts of the body.

"The bones of the upper extremity may be involved in the following order of frequency:

"(*a*) Forearm (radius and ulna).

"(*b*) Arm (humerus).

"(*c*) Hand (carpal, metacarpal and phalanges—proximal and distal).

"The bones of the lower extremity may be also involved in the following order:

"(*a*) Leg (tibia and fibula).

"(*b*) Thigh (femur).

"(*c*) Foot (tarsal, metatarsal, and phalanges—proximal and distal).

"In regard to age, the bone lesions are usually observed in persons with a history of smallpox during early childhood, but the deformity may follow variola contracted at any time before the complete ossification of the bones. The greatest age at which such a complication of variola has been observed was fourteen years, in a boy.

"The fact that practically no mention of bone-deforming lesions as a complication of variola is found in current literature should make one very cautious not to interpret coincidence as cause and effect. The fact that the masses of the Filipino people are undernourished and underdeveloped as a result of starvation and metabolism incongruities adds to the difficulty of definite conclusions in interpreting the etiology of chronic bone-deforming lesions contracted during childhood.

"Both scurvy and rickets are much less frequently encountered in Manila than

[1] Musgrave, W. E. and Sison, A. G. The bone lesion of smallpox. *Philippine J. Sc.*, April, 1913.

*Read at the Twenty-third Annual Meeting of The American Roentgen Ray Society, Los Angeles, Calif., September 12–16, 1922.

FIG. 1. Lateral view of both ankles.

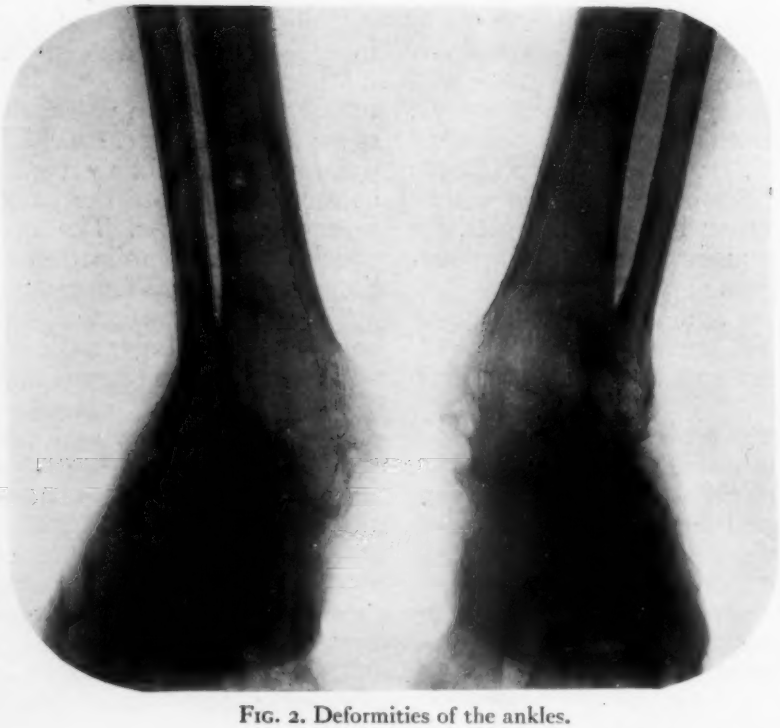

FIG. 2. Deformities of the ankles.

would be expected from the habits and faulty feeding customs of the people, and these diseases are less frequent in our large clinics than is reported from similar clinics in other parts of the world.

"The pathology of these disturbances, their mode of onset, and the course and results are now pretty well known, and do not correspond to the conditions found in our smallpox cases sufficiently close to make the danger of mistake in diagnosis a serious consideration.

The process appears to be due to destructive lesions in the epiphyses of the bones. The shafts of the ulna and radius seem to be normal, except in length. The ends of the bones are enlarged and irregular in shape, and similar changes may be encountered in the carpal, metacarpal, and phalangeal bones.

"The circumferential growth of these bones is not disturbed in the least. There is no sign of underdevelopment in diameter, thus proving that the periosteum upon

FIG. 3. Bone deformities of the right foot.

"The close resemblance in the character of the deformities, their constant association with a history of smallpox during early life, and the absence of similar lesions under other conditions seem to warrant the conclusion that the deformities are a complication of variola.

"The morbid anatomy and histology of the lesions and deformities have been studied in one case by Crowell (Case III).

"In our preliminary report we stated: which the circumferential growth depends is not affected.

"The bones are markedly shortened and stunted in longitudinal growth; in some cases they are reduced to less than one-half the length of the normal bone. The obvious conclusion from this fact is that the seat of the primary lesion is in that part of the bone between the epiphysis and diaphysis which develops actively *ex utero*."

From their report of cases the following are taken:

CASE I (No. 6992, 1912). Female, Filipina, twenty-seven years old, seamstress, born in Malabon. She had smallpox during childhood, and as a complication she developed deformity of the left elbow-joint, with partial ankylosis and shortening of the bones of the left arm and forearm.

CASE III (No. 2464, 1912). Female, single, washerwoman, aged thirty-two, born in Silang, Cavite. Had smallpox when a little girl, with subsequent deformity of the elbow-joints and left wrist, with distinct shortening of the bones of the forearms on both sides. Deformity of both

FIG. 4. Bone deformities of the left foot.

CASE II (No. 5368, 1912). Male, Filipino, born in Mindoro. Had smallpox when a little boy, and as a complication he developed deformity of both elbow-joints with marked shortening of the bones of the forearms and slightly of the arms, with partial ankylosis of both elbow and wrist joints. Deformity also of both knee-joints and some shortening of the bones of both legs.

knee-joints and distinct shortening of the bones of both legs exist, with partial ankylosis of the elbow-joints.

This patient died on March 22, 1912, and autopsy was performed by Dr. B. C. Crowell. Musgrave and Sison, in summarizing the bone conditions found by Crowell, say: "It is apparent that the diaphyses

of the bones are shorter than normal, and that the ends of the bones, representing the original epiphyses, are much altered in configuration. In the shafts of the bones which were removed for examination there is no apparent change from the normal in contour or diameter. Mesial longitudinal sections through the ends of the bones show complete ossification of the epiphyseal extremities, and no indication of the line of junction between the epiphyses and diaphyses is present. The deformities of the epiphyses must, therefore, have occurred before the period of full growth, and the interference with the longitudinal growth of the diaphyses must have been due to some disturbance at the line of junction with the epiphyses.

"As is to be expected from the above description of the condition of the bones, examined at a period after the cession of active disease and after healing has taken place, the microscopic examination of the bones shows nothing which will further elucidate the nature of the active process. Complete ossification has taken place, and decalcified sections of the bones show no alterations from the normal condition of bone growth at this period of life. The epiphyseal line of growth is obliterated, and the compact bone and marrow bear normal relations. The only alteration is in the size and conformation of the epiphyses."

There were a number of other cases reported, but these few will serve to show the character of the deformities that these men have found.

FIG. 5. Showing the continuous medullary canal from the humerus to the radius and ulna.

MY OWN CASES

I have personally seen two cases that I have recognized.

CASE I. A Chinese woman of about twenty-seven years, who gave a history of smallpox when three or four years of age. At the time seen she had deformities of both wrists and shortening of the right humerus and the bones of the right forearm. By measurement, the right humerus was 1 in. shorter than the left, and the bones of the right forearm were 1 in. shorter than those of the left. The ulna

in each forearm appeared to be longer than the corresponding radius, causing deformities of the wrists. No roentgenograms of this case were possible.

Case II. A Chinese, male, aged sixty-seven. Entered the hospital for pains in the feet. He was sent to the roentgen-ray department for roentgenograms of the feet and ankles. The films showed fusion of the distal extremities of the tibia and fibula. These also were fused with the astragalus. The first and fifth metatarsals of both feet showed shortening. From a diagnostic standpoint, the shortening of the bones and the deformities of both feet were probably the sequelae of smallpox. Under the fluoroscope, deformities of the hands and right elbow were noted.

Films of the right elbow show complete absence of articulation, and complete fusion of all bones. So complete is this fusion that the medullary canal of the humerus can be followed directly into that of the radius and that of the ulna. (This is the real three-in-one.)

The left hand shows marked shortening of the fifth metacarpal, and also a smaller shaft than the right fifth metacarpal.

Fig. 6. Metacarpal changes of the left hand.

The right hand shows shortening of the first, second, and fifth metacarpals. Of these short metacarpals, there is but one that has a smaller shaft than normal. This is an exception to the statement of Musgrave and Sison quoted above, for they found no bones of lessened circumference.

The history of this man showed no bone injury, no evidence of inflammatory troubles, and no pains or aches until within

the last six months, but there was a history of smallpox at the age of three years.

Physical examination shows no difference in the length of the two arms, but because of the ankylosis of the right elbow, the circumference of the right arm and forearm is less than that of the left. Examination of the mouth revealed a very marked pyorrhea, which, in all probability, was the origin of the infection causing pain in the feet.

The cases so far reported are from the Orient. Therefore I raise the question: Is the particular variola of the Orient different from that of the Occident, or are we simply not recognizing these cases?

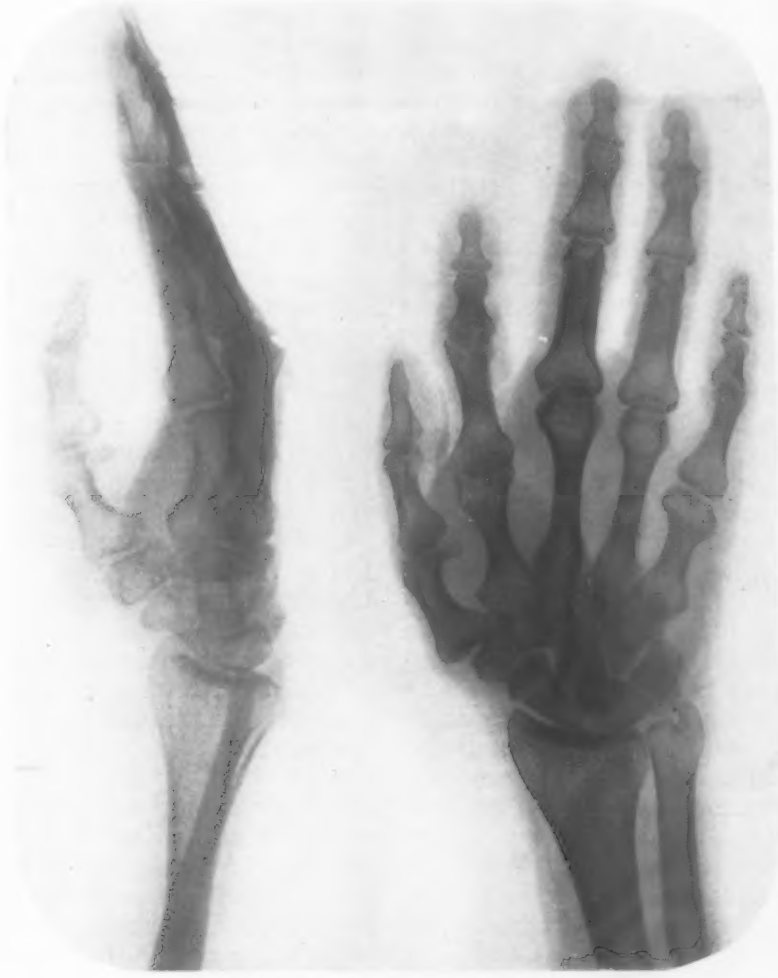

FIG. 7. Metacarpal changes of the right hand.

Since reporting the above cases, one case has been reported by Dr. W. L. Brown of El Paso. This was of disease contracted in Mexico; therefore, it is not an oriental complication.

THE DIAGNOSIS AND TREATMENT OF BONE LESIONS: A BRIEF SUMMARY OF THE SALIENT FEATURES*

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I WILL attempt to give you briefly the salient facts which I have harvested from more than 1,000 records of bone lesions. This includes only those cases of tuberculous and pyogenic osteomyelitis which resemble clinically and in the *x*-ray a possible periosteal or central malignant lesion.

The Routine of an X-Ray Examination. With rare exceptions this should include the corresponding bone as well as the diseased bone. Especially is this important when the lesion is of slight extent and its interpretation obscure. My records show frequent mistakes due to this neglect. For example, a lateral view was taken of the tubercle of the tibia, because the child, aged ten years, had a painful swelling in that region, following a trauma. It was interpreted as a possible sarcoma, and exploration advised. When the roentgenogram was made of a similar aspect on the opposite side, it developed that the beak-shaped process of the tibia was even more suggestive of disease than on the evidently involved side. Nothing was done, and the child recovered without an unnecessary operation.

Roentgenograms Immediately after Trauma to Bones and Joints. We have educated ourselves and the public to the routine *x*-ray examination in cases of evident or possible fracture. But a similar examination is not being made as a routine procedure after a contusion of bone or sprain of a joint. This examination is essential for more than one reason, and perhaps the least important is the bringing to view an incomplete fracture. Such an examination will reveal the condition of a bone or bones at the time of the injury, and may reveal a preexisting osseous lesion, and—most important of all—is a record for comparison if the trauma excites some benign or malignant pathological process.

In only two of all my cases of sarcoma after trauma, do we have roentgenograms which were made directly after the injury, showing a normal bone, and later ones, clearly demonstrating the development of sarcoma.

In the past two years, due to the fact that both physicians and roentgenologists are realizing the importance of this routine examination, I have accumulated numerous roentgenograms made immediately after a contusion or a sprain which show a definite preexisting bone lesion. In the majority of cases, the lesion has been a partially or completely healed bone cyst; a few showed healed tuberculosis. (*Minn. Med.*, 1922, v, 604.) This examination, directly after an injury, is of additional importance in relation to the workmen's compensation laws and accident insurance.

X-Ray Examinations of Multiple Bone Lesions. It is now well established that the skeleton may be the seat of multiple lesions, and yet only one lesion may attract the attention of the host by pain or swelling. Therefore, it is a good plan to make examinations of all bones. It is my opinion that this should be done in almost every case. When the *x*-rays show multiple, distinctly central lesions, we can practically exclude primary sarcoma, and the diagnosis rests between metastatic carcinoma, multiple myeloma, multiple bone cysts and chondroma. When a distinct periosteal multiple lesion is found, we can exclude malignancy—either sarcoma or metastatic carcinoma. There may be a few exceptions to this rule. For example, a patient suffering with Paget's disease of the skeleton, which is a multiple periosteal lesion, may develop a periosteal sarcoma of one bone. I think I have such a case under observation now, which I reported in the *Journal of Radiology* for August, 1922, as an example of multiple infectious ossifying periostitis.

The demonstration of multiple exostoses excludes malignancy. It is a congenital hereditary disease of the skeleton.

* Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

X-Ray Examinations of the Skull. Recent experience has taught me that it is difficult to distinguish between a primary periosteal lesion of the skull and a central lesion which has perforated and broken through. In a recent clinic in Portland, Oregon, Dr. Sommers brought in a man with an evident periosteal lesion of the shaft of the femur and multiple lesions of the skull. I interpreted them as of periosteal origin, and naturally concluded that the bone lesion was inflammatory. Yet, a few days later, when Dr. Sommers explored the femur, he found sarcoma.

The interpretation of roentgenograms of the skull in relation to evident foci in the long bones is not yet firmly established, and needs further investigation.

I, therefore, urge that before making a diagnosis of a single bone lesion, roentgenograms of other bones be made.

Roentgenograms of the Chest. This should be a routine examination. In a number of my cases of periosteal sarcoma, within three months after the observation of the first symptom, we have found evident metastasis to the lungs in the routine roentgenograms before the patient exhibited any clinical symptoms. The demonstration of evident tuberculosis in the chest is very suggestive that the bone lesion is also tuberculous. Up to the present time, I have not found tuberculosis of the lungs in cases of sarcoma of bone—of this I am positive. Nor do I remember it being associated with bone cysts, giant-cell tumors, chondromas or myxomas. But this point has not been verified recently.

Palpation. I urge all roentgenologists to develop their sense of touch for diagnostic help in reading the films. Again and again cases have come under my observation in which the palpation of the periosteal bone lesion excluded the sarcoma which had been diagnosed from the roentgenogram. When the palpation of the periosteal bone formation shown is as evidently bony as the feeling of your own shin bone, you can be quite certain that it is not malignant. At the present moment, I do not remember having received a single report from a roentgenologist in which there is a note on palpation.

When you palpate about the bone a soft-part tumor, and the *x*-ray film shows that this tumor is composed only partly of new periosteal bone, then you have definite evidence that the lesion is periosteal or a soft-part lesion with secondary involvement of bone. But, unfortunately for the simplicity of diagnosis, and fortunately for the patient, this by no means indicates sarcoma.

As far as my own experience goes, I am just beginning to learn the value of the association of palpation with the study in the roentgenogram of the bone changes and the soft-part tumor, and I record here only those points which, I feel, are established.

Spindle-shaped Periosteal Growth Surrounding the Bone. In the older textbooks and the literature this was looked upon as pathognomonic of sarcoma. My experience teaches the contrary. In the *Journal of Radiology* for March, 1920, I have illustrations of a roentgenogram (Figs. 81 and 82) of a femur about which, on palpation, there was a distinct periosteal and soft-part growth which was not entirely composed of bone. It was interpreted as sarcoma; the advised amputation was refused, and the patient is well today, more than eight years since the first observation. I have again reported this case in the *Journal of Radiology* for August, 1922, with other examples of "infectious ossifying periostitis" in which similar spindle swellings have been observed.

X-Ray Findings in the Soft Parts. Not infrequently, when palpation fails to reveal any evident tumor outside the bone, the roentgenogram may show it. This is a very important change to look for, because the demonstration of soft-part involvement by palpation or in the *x*-ray film outside the cortical layer indicates periosteal involvement, irrespective of whether the appearance of the bone suggests a central lesion or not; and this is essential in planning the mode of attack—a point which I will discuss later under the title Central and Periosteal Bone Lesions.

Calcified Areas in the Soft Parts Outside the Bone Involved. My experience, as yet, is too limited to write positively, but, especially when the bone lesion is near a

joint, the evidence in the roentgenogram of darker areas suggesting calcium deposits with a definite clear area between them and the bone, or the new periosteal bone formation, is very suggestive of tuberculosis, and against sarcoma.

Other Routine Examinations. My records show that it is a grave mistake for the roentgenologist to attempt to make a diagnosis from the *x*-ray plate alone. He can describe what he sees in detail and give his interpretation, but this interpretation is often modified by other laboratory findings and the clinical picture. It should be the duty of the roentgenologist, when he is asked to make an examination, to insist upon a complete *x*-ray examination and urge, before his final opinion is given, that he know the clinical history and the result of the other laboratory investigations. Unfortunately, the records sent to me with *x*-ray films or plates, are usually incomplete in this respect.

In every patient with a lesion of bone, there should be a Wassermann test, a complete blood examination, an examination of the urine for Bence-Jones bodies, and a search for foci of infection in the tonsils, nasopharynx, teeth and in the genitourinary tract. The urine should be repeatedly examined for the Bence-Jones bodies, and there should be always a differential count of the white cells of the blood.

Diagnostic Salvarsan. When the roentgenogram shows an evident periosteal lesion and the Wassermann is negative, I always advise at least one dose of intravenous salvarsan. It is true that in the majority of cases of syphilitic periostitis, the Wassermann has been plus. But when I have given these patients salvarsan, the evident improvement in the local condition has been so rapid and so marked that it occurred to me years ago to use it as a diagnostic test. I now have four cases in which the Wassermann report was negative, the *x*-ray plate strongly suggested sarcoma, and after salvarsan intravenously, there was rapid improvement and a permanent cure.

Incomplete Examination. Numerous records have been received with the diagnosis of periosteal sarcoma, requesting advice as to whether the treatment should be amputation, or roentgen or radium therapy, but without a Wassermann test. The diagnosis has been often changed and a cure immediately established by making a Wassermann test.

Only in recent cases have the records reported an examination for the Bence-Jones bodies. In my experience the presence of Bence-Jones bodies in the urine establishes the diagnosis of an incurable disease—either multiple myeloma, or metastatic carcinoma.

Localization of Lesion. In a recent complete study (about to be published) of all the central and periosteal lesions of the phalanges, we found a single example of a central sarcoma of a phalanx, and no case of perisoteal sarcoma. This is an important point to remember. The diagnostic value of the localization in other bones, up to the present time, gives only approximate diagnostic help. For example, in the central lesions of the lower end of the radius, the chances are 90 per cent that it is the giant-cell tumor. Periosteal and central lesions of the metacarpal, metatarsal and tarsal bones are very rarely malignant; up to the present time I have not observed any lesion of a carpal bone, except inflammatory, usually tuberculous.

This point of the localization of the different possible bone lesions has not yet been worked out up to date for all bones.

Central Bone Lesions. If the *x*-ray examination shows a distinct central lesion with definite bone shell, with or without fracture, and no extra-osseous soft-part lesion, and palpation reveals nothing, and the patient is under fifteen years of age, we can be quite certain that it is not sarcoma, nor any other malignant tumor. The probabilities are that it is a bone cyst. The next possibility is the giant-cell tumor, rarely a chondroma, and, in a very few instances, tuberculosis. In my experience, operation is not indicated at once. One can watch the case under control of frequent *x*-ray examinations. This is especially true when there is a pathological fracture. This fracture cures the bone cyst, with rare exceptions, and subsequent roentgenograms will reveal the rapid ossifi-

cation, not only of the fracture, but of the central area of destruction. When rapid ossification does not show, operation is indicated at once. This operation will hasten the healing of the bone cyst, and is the best treatment for the giant-cell tumor or chondroma.

My experience teaches me that when the roentgenogram shows no fracture, an operation promises a more rapid and permanent ossification if the lesion proves to be a bone cyst, and, of course, as said before, this is the best treatment for the giant-cell tumor and chondroma.

If the patient is over fifteen years of age, and the roentgenogram shows a central lesion with a definite bony shell, with or without fracture, my evidence indicates that nothing is to be gained by delay; sarcoma cannot be excluded. It is also very important to remember that the single central lesion may be the onset of a multiple myeloma before Bence-Jones bodies appear in the urine, and in which the other foci in the marrow do not show in the film. Also, it may be the first evidence of metastasis from a concealed primary malignant tumor, especially in the kidney and prostate. These two possibilities, however, are very rare.

The order of frequency of central bone lesions after the age of fifteen is as follows: Benign giant-cell tumor; the recent and the old unhealed bone cyst; the sarcoma; the chondroma; the myxoma.

My experience up to date seems to show that *x*-ray and radium therapy cannot be expected to affect the pathological process through a bone shell; moreover, when radiation therapy is used, it is employed largely for conditions in which it is neither necessary nor valuable.

The Method of Attack of Central Bone Lesions. When the roentgenogram shows a single central lesion, with or without fracture, in a patient over fifteen years of age, operation is indicated. The object of the operation should be to remove and destroy the pathological tissue within the bone shell, with a technique to prevent, as far as possible, the implantation into the soft parts of tumor tissue. This implantation is most dangerous in myxoma and next in chondroma. For this reason, under an Esmarch, I expose the bone shell, open it with the electric cautery, and unless I am confident that it is a benign bone cyst, I remove the tissue within the bone shell, using the hot iron as a curette. Then I swab the cavity with pure carbolic and alcohol; then I pack it with gauze saturated with 50 per cent zinc chloride. If the evidence is in favor of sarcoma, I would implant the cavity with radium and follow with postoperative radium or *x*-ray treatment. This method is unnecessary for the benign bone cyst, but it does no harm, and interferes very little with healing. It is essential for the myxoma, chondroma and the giant-cell tumor, except the employment of radium and *x*-ray therapy, which need only be used if malignancy is questionable.

The wound can be left open or closed, according to its size.

My personal experience with immediate bone transplantation into large cavities has been unfavorable, except in the bone cyst, in which, however, it is not necessary.

The Cure of Central Sarcoma. In the *Journal of Radiology* for March, 1920, I recorded four cases diagnosed central sarcoma in which the patients are living five years after operation. I now retract two. Pathol. No. 20115 (Fig. 12) is diagnosed on restudy by a number of consultant pathologists as a giant-cell tumor. Pathol. No. 19179 (Fig. 23) has now been placed by consultant pathologists as an example of an unhealed benign bone cyst. Pathol. No. 10602 (Fig. 26) has died of metastasis. This leaves but one undisputed example of a central sarcoma cured by amputation (Pathol. No. 14229, Fig. 29).

The probability of a cure of a central sarcoma after amputation is less than 10 per cent.

Among the recent cases, there is one in the upper end of the humerus, operated on by Dr. Bunts of Cleveland, that we feel is sarcoma. The patient is now well, almost two years after operation. The method of attack was somewhat on the lines indicated here. Then there is another case from the Mayo Clinic, which recurred after curetting, but not with thermal or chemical cauterization. This patient has

also remained well now, more than five years since amputation.

In view of the fact that amputation has rarely cured the central sarcoma because of metastasis to the lungs, and because it is the rare central lesion and often difficult to differentiate from some variant of the bone cyst and the giant-cell tumor, it seems to me we are justified, when we have a central tumor of bone, with an intact bone shell, in using this method of treatment, even when the gross appearance at operation and the microscopic picture strongly suggest sarcoma.

I have previously reported this method of attack in central sarcoma in *Minnesota Medicine* (not yet published), and now have in preparation a more detailed contribution.

Perforation and Destruction of the Bone Shell. This is not diagnostic of malignancy. Perforation of the shell has been observed in chondroma and the bone cyst, and partial and complete destruction of the bone shell has been observed in the giant-cell tumor. This point has been fully described by me in *Annals of Surgery* (April, 1919).

Since the publication of this paper, two years ago, I have received the records and roentgenograms of a giant-cell tumor of the lower end of the radius, in which there was complete destruction of the bone shell with infiltration of the soft parts. Yet the surgeon had the courage to curette, and to transplant bone into the defect, and was rewarded by a permanent cure with very good function.

My records show numerous amputations for benign central giant-cell tumors, because diagnoses were made of sarcoma on account of the perforation and partial or complete destruction of the bone shell.

Periosteal Bone Lesions. The problem of diagnosis and the plan of attack are essentially different from those advocated for central bone lesions. Age is of no help in diagnosis. It is very difficult in many instances to distinguish the periosteal sarcoma with and without bone formation, from the benign periosteal lesions with and without bone formation. I have described these in the *Journal of Radiology* for March, 1920, and again in August, 1922.

Up to the present time, I have but two permanent cures after amputation for periosteal sarcoma—less than 4 per cent, and recently two cases which reacted favorably to radium. In one, it is permanent now two years; in the other, there has been a recurrence after eighteen months, but improvement is showing again after radium treatment.

The Method of Attack of Periosteal Lesions. At the present time, even with a very large experience, I am somewhat in doubt. I feel positive that each case should first receive salvarsan, and then *x*-ray and radium treatment. If there is no evident improvement, I am of the opinion that amputation should not be done without a microscopic diagnosis, except in those cases of periosteal sarcoma in which the diagnosis can be made positively with the roentgenogram.

In some surgical clinics, where the surgeon, or his surgical pathologist, is capable of making a correct diagnosis with a small element of error, the decision as to amputation can and should be reached at the exploration. In other clinics, where as yet the surgeon and his pathologist have had less experience, the element of error thus being larger, a piece should be excised with the cautery and sent to a number of pathologists for diagnosis.

Recent experience has demonstrated that the number of benign periosteal lesions of single bones resembling in the *x*-ray films and clinically periosteal sarcoma, is increasing. These patients got well spontaneously, before the days when patients came early for diagnosis and treatment. These benign periosteal lesions are: Ossifying periostitis, traumatic, infectious, syphilitic, tuberculous; exostoses, and some rare examples of osteomyelitis. Therefore, in view of the fact that the cure of a periosteal sarcoma is so infrequent even after amputation, and the possibility of error is yet so large, amputation should be considered only when other means have failed. It is important to remember that when the lesion is syphilitic, the favorable reaction to salvarsan will be rapid. If we are to see the good effects of radium or the *x*-rays, it should be at once, within two weeks. My experience is chiefly with

radium; with ordinary *x*-ray therapy I have observed no results.

Unfortunately, in the traumatic and infectious ossifying periostitis, which, when it involves one bone, is characterized by great difficulty in the differentiation from sarcoma, but the lesion recovers very slowly, there is no reaction to salvarsan, and in my experience little benefit accrues from *x*-rays or radium therapy. For this reason, although the periosteal lesion shows no improvement after salvarsan or radium therapy, we must still consider the possibility of spontaneous recovery in the case of traumatic and infectious ossifying periostitis.

Of this latter group I have made a full report on my experience up to date in the *Journal of Radiology* for August, 1922. This lesion, which I take the liberty of naming infectious ossifying periostitis, because it resembles infectious arthritis, has been described in the older literature by Garré as *non-suppurating osteomyelitis.*

Conclusions. This summary demonstrates how much we still have to learn in the diagnosis and treatment of bone lesions.

I venture to suggest that further great advance must rest upon the accumulation of complete records with the follow-up system which can be restudied from time to time. All have a large opportunity to join and be helpful in this investigation.

BIBLIOGRAPHY*

Results of operations for sarcoma of bone. Discussion of Dr. John A. Wyeth's paper. *Ann. Surg.*, 1901.

Giant-cell sarcoma of bone. Report of a case of medullary giant-cell sarcoma of upper end of tibia in which tumor was apparently completely removed by chiseling without destroying the continuity of tibia, and a discussion of the facts which justify this more conservative procedure. *Johns Hopkins Hosp. Bull.*, May, 1903, xiv.

Bone cysts. *Jour. Am. M. Assn.*, Oct. 15, 1904.

Conservative operations on bone tumors. Based on the clinical and pathological study of the relative degree of malignancy. *Jour. Am. M. Assn.*, Feb., 1908.

Benign bone cysts. Ostitis fibrosa. Giant-cell sarcoma and bone aneurism of the long pipe bones. *Ann. Surg.*, 1910, lii.

The conservative treatment of giant-cell sarcoma with the study of bone transplantation. *Ann. Surg.*, Aug., 1912, lvi.

Bone tumors. Central (medullary) giant-cell tumors (sarcoma) of lower end of ulna with evidence that complete destruction of the bony shell or perforation of the bony shell is not a sign of malignancy. *Ann. Surg.*, Apr., 1919.

Bone cysts of the marrow of long pipe bones, benign and malignant. *Tr. M. Ass. Alabama*, Apr., 1919.

Bone tumors benign and malignant. A brief summary of the salient features. Based on a study of some 370 cases. *Am. J. Surg.*, Sept., 1920, xxxiv.

The diagnosis and treatment of benign and malignant tumors of bone. *J. Radiol.*, Mar., 1920.

Bone tumors. Central in the phalanges in the fingers and toes. Chondroma, myxoma and giant-cell tumors. *Jour. Orthop. Surg.*, Nov., 1920, ii.

Bone tumors. Myxoma, central and periosteal. (Their recurrence after exploratory incision and piecemeal removal.) *Ann. Surg.*, Dec., 1920.

Bone tumors. Benign bone cysts and ostitis fibrosa. *X*-ray—gross and microscopic features. *South. M. J.*, Dec., 1920, xiii.

Bone diseases. Non-suppurating osteomyelitis (Garré). Infectious ossifying periostitis (Bloodgood). *J. Radiol.*, Aug., 1922, iii, pp. 310–317.

Central bone tumors and their differential diagnosis; with special reference to the latent and unhealed bone cysts in adults. *Minn. Med.*, Oct., 1922, v, pp. 604–610.

Bone diseases, osteoporosis or lipomasia from fixation and non-use. *J. Radiol.*, Oct., 1922, iii.

* The author's contribution to the literature on bone tumors.

IONIZATION MEASUREMENTS*

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DURING the last few years ionization measurements have assumed considerable importance in radiation therapy. It may be well, therefore, to summarize briefly the essential facts of such measurements, in order that this information may be easily available to the radiologist.

Ionization. The atomic structure of electricity, as well as the atomic and molecular structure of matter, is now firmly established. Electricity is made up of minute but discrete negative "particles" called electrons, and positive particles which, so far, have been found to be always associated with matter. We can say also that matter is entirely of electrical nature and is made up of groups of positive and negative particles variously arranged. Atoms and molecules are normally neutral, that is, the positive electricity is completely balanced by an equal amount of negative electricity. But under certain conditions a temporary unbalance may be brought about.

It is well known that some chemical substances, when dissolved in water, break up to a certain extent into positively and negatively charged parts. These were named *ions* (that is, wanderers). In recent years the term has been extended to include any atom or molecule or group thereof in any medium carrying a charge of electricity. The process of producing ions is called *ionization*.

The radiations of radium and *x*-rays have the property of ionizing substances in the extended sense. That is, they are capable of producing positively and negatively charged particles in a substance, through the liberation of electrons from the atoms. It is important to distinguish between this type of ionization and electrolytic dissociation. In the latter case the ions are produced when the substance is dissolved in water, and no other agency is necessary. A number of molecules break up in a certain definite way, forming the required number of ions to establish equilibrium. The ions then persist as long as the substance remains in solution. On the contrary, the other type of ionization is dependent on an external agency such as radium, and gradually disappears if the agent ceases to act. The extent to which the substance is ionized depends on the ionizing agent. But in any case, a very small fraction of the total number of molecules are in the ionized state at any one time.

Electric Current. Knowing that water is made up of molecules, we can think of a current of water as the migration of these molecules from one point to another. In an analogous way an electric current is nothing but a number of electric charges in motion. The carriers may be electrons or ions, or even dust particles. The essential thing is that electric charges be in motion. Just as a force must be applied to set water in motion (usually the force of gravitation) a force must be applied to the electric charges to produce the current. Such a "force" is called an electromotive force (e.m.f.) and is ordinarily expressed in volts. The terms "potential" and "voltage" are also used to express the same thing.

To form a mental picture of the flow of electricity, let us examine the circuit of Figure 1. *G* is an electric generator, *A* and *B* its terminals. The function of the generator (whatever its construction) is to pump electrons from *A* to *B* so that in consequence *A* becomes positively and *B* negatively charged. The more electrons the generator tends to crowd into the terminal *B*, the higher will be the "pressure" or voltage of the machine. Metals possess the property of having free electrons, that is, electrons which are capable of moving between the molecules. If we connect *A* and *B* by means of a wire, the electrons in the metal will be attracted by *A* and repelled by *B* and, therefore, will

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travel from *B* to *A* along the wire. This would soon neutralize the positive charge at *A*, were it not for the fact that the generator pumps the same number of electrons away from *A* and back to *B*. A fresh supply of electrons can then pass through the wire which closes the circuit. Since, however, the molecules of the metal offer a certain resistance to the passage of the electrons, a condition is soon reached in which the opposing force is equal to the actuating force. At this point there is a continuous current passing through the whole circuit depending in value on the e.m.f. of the generator and the resistance of

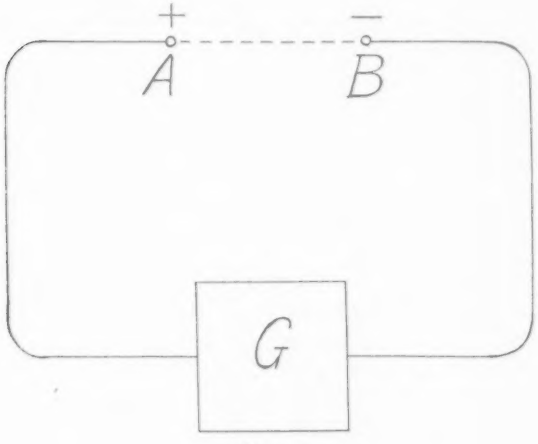

FIG. 1.

the circuit. In this example the energy supplied by the generator is all used up in overcoming the frictional forces encountered by the electrons in passing through the molecules. It appears as heat in the wiring of the whole circuit.

Ionization Current. If to the terminals *A* and *B* we connect two parallel metal plates insulated from each other by an air space, no appreciable current flows in the circuit, even though the e.m.f. be quite high. The reason is that ordinary air contains no free electrons and only a very few ions. Allowing a beam of *x*-rays to pass through the air results in the formation of ions, and a current is established. The negative ions travel toward the positive plate and the positive ions toward the negative plate. The magnitude[1] of the current depends on the number of ions reaching the plates per second.

In speaking of ionization it was mentioned that the ions soon disappeared after removal of the source of ionization. The reason for this is that the ions of opposite sign sooner or later come in contact and neutralize their charges. Evidently the same process takes place while the radiation traverses the gas, and the number present at any time is the difference between those which have been formed and those which have recombined. Accordingly the number of ions which reaches the charged plates per second is not necessarily the same as the number produced by the radiation, for some may have recombined *en route*. Obviously, the shorter the time interval between the instant they are produced and the instant they touch the plates, the less chance they have for recombination. The speed of the ions, other conditions remaining the same, depends on the voltage between the plates—the higher the voltage the faster the speed. So that, evidently, if the voltage is high enough, all the ions may reach the plates before any recombination has occurred. When this condition is realized, we obtain the maximum current which the degree of ionization of the air permits. This is called the *saturation current*, and can be taken as a measure of the number of ions produced per second in the air between the charged plates by the radiation. It is, perhaps, hardly necessary to mention that the farther apart the plates are, the higher the voltage must be to obtain the saturation current. Also the more intense the ionization is, the higher the voltage must be, since recombination can take place more easily.

From the preceding discussion it is apparent that to establish an ionization current, in addition to the presence of ions, it is necessary that they travel to the charged plates. Furthermore, to obtain saturation current it is necessary that they reach the plates before they have had an opportunity to recombine. The mobility of the ions is, therefore, an important factor in this connection. In gases they can move freely. But remembering that ions are always of molecular dimensions, we can

[1] It may be well to state here that ionization currents of this type at best are extremely small in comparison to the conduction current previously described.

readily see that their motion must be considerably impeded in solids and liquids. Therefore, in spite of the much more intense ionization on account of the closer packing of the molecules, ionization currents[2] in solids and liquids are, in general, much smaller than in gases. In addition, it is very difficult to obtain saturation current. In practice, air or some other gas is ordinarily used as the ionizable medium.

Measuring Instruments. We have seen how saturation current is obtained when the ions are carried to the charged plates before they have had a chance to recombine. Under these conditions the resultant electric current is a measure of the number of ions produced per second in the air between the plates by the ionizing agent. Therefore, if we determine the value of the saturation current we know the degree of ionization in the air, and, if we wish, the number of ions produced per second. Ionization currents of this type are extremely small in comparison to ordinary electric currents. For their measurement, therefore, very sensitive electrical instruments must be employed.

All instruments for ionization measurements consist of three essential parts: (1) The ionization chamber in which the ions are produced; (2) the electrical instrument which is to measure the ionization current; (3) a suitable connection between the two. A source of potential is also necessary.

The ionization chamber can be of any desired shape or size. In its rudimentary form it consists of two electrically conducting surfaces properly insulated from each other and with an air space between them. The whole should be enclosed in a metal case or other conducting envelope and grounded, to avoid electrical disturbances and air currents. The voltage to be applied to the insulated surfaces to obtain saturation current depends on the distance between them and the intensity of the radiation to be measured. The pressure of the air or gas in the chamber has an influence on the minimum voltage to be used. In general, air at atmospheric pressure is made use of and the voltage applied is higher than is actually needed.

The electrical instrument used must be capable of measuring a very small electric current. Ordinary ammeters or milliammeters or even microammeters are not sensitive enough for the usual ionization measurements. The most sensitive galvanometers made can be used, provided the ionization current is sufficiently large. The operation of a galvanometer is based on the fact that a coil of wire through which a current flows becomes magnetized, and that the degree of magnetization depends on the strength of the current. In a galvanometer the electromagnet thus formed is made to interact with a permanent magnet, and motion of either one of them results. In the D'Arsonval galvanometer the coil is suspended between the poles of a permanent magnet by means of a very fine silver strip. To the coil is attached a small mirror, and the two turn through an angle when a current passes through the coil. By projecting a beam of light on the mirror, the reflected beam can be made to move over a scale and the motion of the coil be thus observed. The light beam serves as a weightless pointer of any desired length, and increases the apparent sensitivity of the instrument. This is the most practical type of galvanometer. The other type (Thompson galvanometer) in which the permanent magnet forms the moving element, while it can be made more sensitive, is more easily influenced by external magnetic fields and is not so reliable. With the D'Arsonval galvanometer of the highest sensitivity made by the Leeds and Northrup Company, currents as small as 10^{-10} ampere[3] can be measured.

A great many ionization measurements are made in which the current is much smaller than that which a galvanometer can measure. In such cases no electrodynamic instrument can be used, and we have to adapt electrostatic instruments for current measurements. The simplest of these devices is the gold leaf electroscope. The essential parts are shown in Figure 2. A strip of gold leaf *G*, about 2 mm. wide and 25 mm. long, is attached

[2] We are referring now to ionization currents produced by external agencies, such as *x*-rays.

[3] 10^{-10} ampere $= \frac{1}{10{,}000{,}000{,}000}$ ampere.

at one end to a flat brass post *P* which is supported on a good insulator *I*. The metal case *C*, which houses the leaf, may be of any desired size and thickness. If the electroscope is to be used with an ionization chamber, a wire, *W*, which is carefully insulated from the case, is connected to the leaf post. The leaf system, including the wire which is connected to one electrode of the ionization chamber, is charged to a voltage of about 300 volts by making contact with a suitable source of potential through the rod *R*. This means that electricity is "pumped" into the leaf system at a certain "pressure" or voltage. On account of the force of repulsion between the electricity in the gold leaf and that in the post, the leaf assumes a position such as at *a*. The higher the charging potential, the farther will the leaf stand out from the post. Each position then corresponds to a definite voltage. If the rod *R* is withdrawn, a definite amount of electricity is left in the leaf system, and the leaf remains away from the post. When the ionization chamber is exposed to radiation, the ions which are formed carry away the electricity from the leaf system more or less rapidly, depending on the intensity of the ionization. As a result, the leaf gradually falls back to its vertical position. The rapidity of motion is proportional to the ionization current. In practice a stop-watch is used to determine the time it takes the leaf to travel, let us say, from position *a* to position *b*. This time is inversely proportional to the value of the ionization current. The motion of the leaf is usually observed by means of a microscope.

A mechanical analogy will make the operation of an electroscope clearer. The charging of the instrument is analogous to the inflating of a tire, the gold leaf corresponding to the pointer of a pressure gauge attached to the tire. If the air compressor is disconnected and there is no leak, the pointer of the gauge remains stationary. We then allow the air to escape slowly through the valve. The faster the air leaks out, the more rapidly will the pointer move toward the zero of the gauge. If we measure the time it takes the pointer to move from the 60 to the 50 pound mark on the dial, for different openings of the valve we can determine the *relative* amounts of air flowing per second for various valve settings. It will be noted that this does not tell us how many cubic inches of air are flowing out per second for any one setting; but simply that for one setting, say twice as much air escapes per second as compared to the flow for another setting. To determine the actual flow of air a special calibration is necessary. Similarly, in the case of the electroscope the readings which we obtain are relative. The analogy can be carried further. The time required by the gauge pointer to travel from the 60 to the 50 pound mark depends also on the capacity of the tire. The larger the tire the more air must flow out for this reduction in pressure. In the case of the electroscope, the larger the electrical capacity of the leaf system, the longer it will take the leaf to move between any two given points. Therefore, to make this time short and thus increase the sensitivity of the electroscope, we should make the electrical capacity of the instrument small.

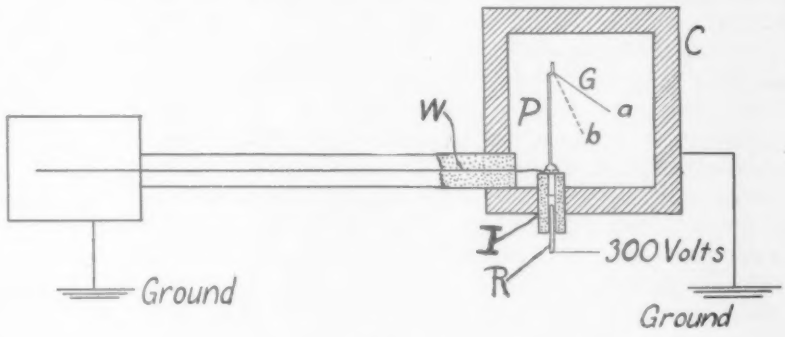

FIG. 2.

An electroscope can be used without an additional ionization chamber, for in itself it is one. The leaf is at a high potential while the case is at ground potential, and therefore if the air is ionized a current can flow between the two. This is the way

an electroscope is used ordinarily. It has then a small capacity and is very sensitive. When used in conjunction with an ionization chamber, special precautions must be taken to make sure that the current we measure is produced in the chamber and not in the electroscope proper. This means that the latter should be as small as possible, and made of thick lead to exclude the radiation which is to affect only the air in the ionization chamber.

We may now contrast the operation of the galvanometer and the electroscope. The former is an electrodynamic instrument, that is, it measures electricity in motion. Corresponding to a given electric current flowing through it there is a definite position at which the coil, and hence the beam of light, comes to rest. It will remain stationary as long as the same current flows through. The electroscope is an electrostatic instrument, that is, it measures electricity at rest. Corresponding to the amount of electricity which the leaf system contains (or what amounts to the same thing, to the voltage of the system) there is a definite position which the leaf will assume. It will remain stationary as long as the same amount of electricity remains in the leaf system. If the electroscope is to be used for current measurements, an additional instrument, that is, a stop-watch, is needed. In this respect it is not so convenient as a galvanometer, but since it is more sensitive it is more suitable for ionization measurements. It is also simpler, more rugged, and requires less attention than a galvanometer.

The third important part of an ionization meter is the electrical connection between the chamber and the measuring instrument proper. This usually consists of a wire with proper insulation. In the case of electrostatic instruments it is important that the wire be as small as possible, to make the electrical capacity of the system small if a high sensitivity is desired. The wire must also be shielded from electrical disturbances. This is accomplished by enclosing it in a metal tube, which is then connected to earth. This tube should be fairly large if a low capacity is required. When penetrating radiation is to be measured by the ionization chamber it is important that the current result only from the ionization in the chamber. For this reason the metal shield for the wire should be filled with a solid insulating substance in which no appreciable ionization current is produced by the radiation. In some cases it is better to make the walls of the tube of sufficient thickness to shut off the radiation from the air in the tube. This precaution must be taken for the electrostatic instrument itself.

The question of the proper substances to use to secure good electrical insulation is of great importance. There are no perfect insulators, but some are better than others. Amber is the best, and sulphur, hard rubber, pure gum rubber, and paraffin are good. Aside from the fact that they are conductors to a slight extent, they exhibit a peculiar property of "absorbing" electricity when in contact with a charged body. This electricity is then given up slowly when the body is discharged. In practical measurements this "soaking action" has the effect of increasing or decreasing the current measured by the instrument, according to the way it is used. Since the degree of soaking depends on the time the insulator is in contact with a charged body and the interval between successive discharges, the error introduced is variable. This is the most insidious source of error in ordinary ionization measurements with electrostatic instruments. Special precautions must be taken to insure uniformity of results.

The leakage of electricity through the insulator, which takes place principally by surface conduction, can be taken care of by applying a correction to the measurements. At the same time, correction is also made for ionization currents which may be set up in parts of the apparatus other than the ionization chamber proper, and for the current which may exist even though the source of radiation may not be acting on the apparatus. The correction is made as follows: The current measured by the instrument when the ionization chamber is exposed to radiation is made up of two parts: (1) that due to the ionization in the chamber produced by the radiation, and (2) that due to any other cause —conduction by the insulators, natural

ionization of the air, stray radiation, etc. If we protect the ionization chamber from the source of radiation, then the only current measured by the instrument is part 2. By subtraction we obtain part 1, which is the current we are interested in. For accurate measurements the "leakage" current (part 2) should be small in comparison to the current we wish to measure. When a galvanometer is used in connection with an ionization chamber, the question of insulation, soaking, etc., is of relatively little importance.

All instruments used for ionization measurements give only *relative* values. A calibration of each instrument is therefore necessary. The unit adopted depends on the use to which the instrument is put. Thus for radium measurements the unit is the milligram of radium element; for radiotherapy it may be the skin erythema dose or any other unit. Whatever unit we select, the instrument, for accurate work, must be calibrated every time it is used, because variations occur over which we have no control. The best way to calibrate or standardize an instrument is by means of a radium tube placed in the neighborhood of the ionization chamber, always under identical conditions.

Radiation Measurements. Ordinarily in making ionization measurements we are not interested in the ionization *per se*, but rather in the radiation which produces it. The intensity of radiation at any given point is defined as the amount of radiant energy passing per second through an area of 1 sq. cm. placed at right angles to the line of propagation at the point in question. It varies inversely as the square of the distance from a point source. To determine it experimentally it is necessary to measure the amount of energy in the form of radiation which falls on a surface of known area during a certain time. In the case of heat or light this is a relatively simple procedure. But in the case of very penetrating *x*-rays or gamma rays it is extremely difficult. There is no instrument which measures radiation as such. Before a measurement can be made, the radiant energy must be transformed into some other form which can be measured. This means that the beam of radiation whose intensity we wish to determine must be absorbed completely. On account of the great penetrating power of *x*-rays and gamma rays, a large mass of matter (such as lead) is necessary for complete absorption. As a result, the energy is distributed through a large volume and is too small to be measured as heat, for instance.

When radiation ionizes a gas, it loses some of its energy, for work must be done to separate positive and negative electricity on account of the force of attraction between the two. If all the radiant energy were used up in producing ions in the gas, and we measured the resultant ionization, we could determine the intensity of the radiation. This, however, is not practical, for the ionization chamber would have to be extremely long.[4] Ordinary ionization measurements are made with relatively small chambers, and so only a small part of the radiation is used up in producing ions within it. This would be no objection, were it not for the fact that the fraction of the radiation thus absorbed is different for different qualities of radiation. Thus a beam of soft *x*-rays may produce an intense ionization, whereas a beam of gamma rays will ionize the gas only slightly, although the total energy in the two beams may be the same. We may conclude, therefore, that ionization measurements of radiations of different quality made with the same instrument do not represent the relative intensities of the radiation. If, however, we measure two beams of radiation of identical quality with the same instrument, the results give us a measure of the relative intensities. These two facts must always be borne in mind in interpreting ionization measurements of radiation.

Aside from the fact that radiation of different quality is absorbed to a different extent by the air (or other gas) of an ionization chamber, there are other factors which must be considered. The electrical instrument, by proper precaution, measures the ionization of the air. This, however, is not produced solely by the primary beam which traverses the chamber. The radiation which impinges on its walls is partly scattered in all directions,

[4] To absorb 99 per cent of the gamma radiation a column of air nearly one-half a mile long would be necessary.

and this scattered radiation will contribute to the ionization. The latter is also increased by the action of the secondary and the characteristic radiations. The relative importance of the different factors which produce the total ionization measured by the electrical instrument depends on the quality of the radiation and the material of which the chamber is made.

Relation between Ionization Measurements of Radiation and Biological Effects. It is very likely that the biological effects of radiation are closely related to the ionization produced in the tissues irradiated. It would be desirable, therefore, to measure such ionization. However, the normal electrical conductivity of tissues is relatively large, so that the increase in the current which can be passed through them, due to the ionizing action of radiation, is completely masked. On this account, what is ordinarily done is to attempt to correlate biological effects and ionization in the air of an ionization chamber. We shall examine this problem to determine, if possible, under what conditions we may expect a parallelism between the two—biological effects and ionization measurements. To simplify our inquiry we shall assume that, other conditions being the same, the biological effect is proportional to the ionization produced in the tissues by the radiation. Our problem, therefore, is reduced to the comparison of tissue and air ionization under different conditions. If we can establish a parallelism between these two, then we *may expect* a parallelism between biological effects and air ionization. On the other hand, if there is no parallelism between tissue and air ionization, we *cannot reasonably* expect a parallelism between biological effects and air ionization.

It has been stated previously that the ionization in the air of an ionization chamber depends not only on the energy which is absorbed by the air from the primary beam, but also on the energy which is absorbed by it from the scattered, secondary, and characteristic radiations set up in the materials of which the chamber is made. We may conclude at the outset, therefore, that the construction of the ionization chamber must be taken into account. Scattered, secondary, and characteristic radiations are also involved in tissue ionization. The relative importance of each depends on the quality of the radiation which gives rise to them, and on the material in which they are set up. It follows, therefore, that if we desire a close relation between tissue and air ionization for different qualities of radiation, we must make our ionization chamber of some material which has nearly the same chemical composition as tissue. Friedrich,[5] after a careful experimental investigation, concluded that for therapeutic *x*-rays a small ionization chamber made of horn and graphite is satisfactory.

Let us consider now some of the measurements which we may wish to make in practice. All ionization measurements in which the quality of radiation remains the same are comparable to tissue ionization. For instance, suppose we give an *x*-ray treatment with a definite set up and we find that an erythema dose is obtained in 60 min. when a current of 3 ma. flows through the Coolidge tube. We then wish to use 6 ma. of current with the same set up, but we are not sure that the milliammeter is calibrated correctly. If the voltage on the tube and the filter are the same in the two cases, the quality of the radiation is substantially the same.[6] Ionization measurements can then be relied upon to give the correct dose for the 6 ma. setting, even though the milliammeter may not read correctly. In this case the construction of the ionization chamber is of little importance. It may be made of a metal or any suitable material. Since the quality of the radiation is the same in the two measurements, the ionization produced in the chamber bears a constant relation to the tissue ionization, irrespective of the intensity of the radiation.[7] That is, let us suppose that the ionization in the chamber is 1 and that in the same volume of tissue is 1,000 when the 3 ma. treatment is given. Then for 6 ma., the two will be 2 and 2,000 respectively, if the meter is

[5] KROENIG, B. and FRIEDRICH, W. Physikalische und Biologische Grundlagen der Strahlentherapie. English translation by Dr. Henry Schmitz.

[6] A slight difference may exist on account of the rectifier in the circuit.

[7] It is, of course, assumed that the necessary precautions as to saturation current, insulation, etc., are taken.

correct. In any case, as long as the same ionization chamber and the same quality of radiation are used, the tissue ionization will be, say 1,000 times larger than the air ionization. Dosage based on ionization measurements under these conditions, therefore, will be quite accurate (provided extreme variations in the time of treatment are avoided). If a different ionization chamber is used, the relation between tissue and air ionization may be 500 or any other figure, but it will remain constant as long as the same chamber and the same quality of radiation are employed.

This fact is made use of in the measurement of radium. Here the air ionization bears a constant relation to the amount of radium placed in a definite position. Double the ionization means double the amount of radium, and so on. The radium content of an unknown tube is then determined by comparing the ionization produced in the instrument with the ionization produced by a known amount of radium. Whether a good instrument is made of brass, lead, or gold has no influence on the result.

The construction of the ionization chamber is also of little importance (provided it is not too large) when dosage measurements are made for different target-skin distances. Here again the voltage and filtration must remain the same in order that the quality of the radiation shall be the same. Both the milliamperes and the target-skin distance can be varied simultaneously, and by ionization measurements, without special precautions, we can obtain the proper dosage.

Before taking up the problem of ionization measurements of radiation of different quality, there is another point which deserves mention. Supposing we have a tube of radium screened by 2 mm. of brass and a few mm. of rubber so that we get only gamma radiation. From clinical experience we may know that if the tube is placed at a distance of 4 cm. from the skin of the patient, a treatment of 2,600 mgm. hrs. will, in general, produce a definite erythema. We should like to know what milligram-hour dose to use to produce the same effect when the same tube is placed directly on the skin. Since the quality of the radiation is identical in the two cases, from what has been said so far we might conclude that the proper dose can be obtained by measurements with any available ionization chamber. This, of course, is not the case, because the distribution of the radiation within the ionization chamber must be considered. In the above example, if a small chamber is used, the rays traversing it are nearly parallel when the tube is placed at a distance of 4 cm., but they diverge rapidly when the tube is placed directly on the chamber. The ionization in the first case is fairly uniform throughout the air of the chamber, but very far from uniform in the second case. While this is also true of the tissue ionization in the two cases, the relative distribution for air and tissue is quite different on account of the much greater absorption of radiation by tissue. Under these conditions we cannot expect a parallelism between air ionization measurements and biological effects.

The question of the relative distribution of ionization within the chamber and in tissue is of still greater importance when radiation of different quality is employed. In such cases a relative variation in the distribution of ionization in air and tissue may take place in spite of the equality of distance. In addition, the relative absorption of the primary, scattered, secondary, and characteristic radiations may be quite different, depending on the difference in the quality of the primary radiation. On this account the ratio between tissue and air ionization does not remain the same, and we cannot expect ionization measurements to check biological effects.[8] When, however, radiations of the same type and slightly different quality are compared, the discrepancy is slight. If, in addition, the ionization chamber is made of organic materials, the quality of the radiation may vary considerably without introducing too large an error for practical purposes. It should be mentioned in this connection that a discrepancy of even 10 per cent is hard to detect in clinical work.

[8] This is clearly brought out by experiments reported in a previous paper (Some problems in radiation therapy, by G. Failla, E. E., Edith H. Quimby, M. A., and Archie Dean, M.D. Am. J. Roentgenol., 1922, ix, 479) where beta and gamma ray doses, empirically determined, were compared with ionization measurements.

In conclusion, we may say that ionization measurements of radiation for therapeutic purposes are reliable, provided the quality of the radiation and the distribution of the ionization in the chamber are not very different for the different measurements. The instrument should be properly designed and constructed as regards the type of ionization chamber, insulation, electrical shielding, screening from extraneous radiation, and saturation. It should be calibrated every day, or oftener if a change is suspected, by means of a radium standard.

COMPARATIVE MEASUREMENTS BETWEEN RADIUM AND X-RAYS CONCERNING ENERGY ABSORBED AT DEPTH*

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THE improvement of the *x*-ray tube has made it possible to raise the voltage of *x*-ray apparatus to 200 kv. or better, and the question has arisen as to whether high voltage *x*-rays can compete with radium in large amounts for external radiation.

The advantage of radium has been that it gives off rays of much shorter wave-length than have yet been obtained by any form of *x*-ray apparatus. Our interest in high voltage *x*-rays was strengthened by the clinical results obtainable with large amounts of radium, and led us to believe that it would be possible with improved output in the matter of short wave-lengths from the *x*-ray tube, to obtain better clinical results than had previously been the case.

Having at our disposal both an adequate amount of radium, and *x*-ray apparatus capable of continuous operation at 200,000 volts, we have attempted to determine the relative penetrating quality of these two agencies by measurements at similar distances and similar distribution.

The effect of radium and *x*-rays upon tissue seems to be proportional to the amount of energy absorbed, whether the rays are hard or soft, *x*-rays or gamma rays. To measure the effective intensity of such rays at a given point, an instrument must be used which absorbs these rays in the same proportion as does the tissue.

Friedrich has perfected a special kind of ionization chamber which accomplishes this result. Following the description given by Friedrich, we have built ionization chambers of this kind, and have used them in the measurements about to be described.

To determine how closely measurements obtained with these instruments approximate the biological reaction of the tissues to radiation, we carried out the following experiments:

1. We wished to determine the erythema dose for a new *x*-ray system where this was not known. With one of the chambers, we measured the intensity at 6 cm. distance from a radium pack, and then the intensity at 30 cm. distance from the target of the *x*-ray tube actuated by a current of 200 kv. Knowing the erythema dose of the radium pack, we were able to compute the skin dose for the *x*-ray system. In actual practice, the computed dose was exactly right. A few months later, when a second machine was installed, we were able to repeat this procedure with the same results. The construction of the two *x*-ray machines was based upon different principles of rectification.

2. The intensity of *x*-rays was measured after passing through a paraffin block 4 cm. in thickness. Adjacent parts of skin were now selected. A computed erythema dose for the skin was given upon the bare skin. The paraffin block was placed upon adjacent skin, and a computed erythema dose for the skin beneath the block was given through the block. The two areas

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of erythema which developed were practically identical, although the time of exposure through the block was twice that of the direct skin exposure.

It is well known that the absorption coefficients of the human body, water, and certain organic substances such as paraffin and beeswax, are approximately the same, and that these substances may be used in experiments to determine the absorption and scattering of radiation projected into human tissues.

These measurements were made with a trough containing water, surface measurements upon the surface of a trough, and depth measurements through the trough, with a second trough behind the ionization chamber to represent tissues of greater depth, the ionization chamber being always placed in the center of the field.

In the experiments made to determine the erythema dose for the unmeasured *x*-ray machines, the wall of the ionization chamber was made of celluloid and graphite, and contained a volume of about 1.5 c.c. The chamber and the electroscope were connected by an insulated wire passing through a brass tube which extends through a lead wall between the operating room and the radiation room, the distance being 8 ft. The measurements were made by taking the time required for the gold-leaf to pass over the same portion of the scale, with corrections made for leakage. In practice, it was proved that the lead wall and distance were not sufficient protection for radium measurements, and for this purpose, a special apparatus had to be constructed. The pack at present used in the State Institute has a radiating surface of 6.5 × 7 cm. At a distance of 6 cm. from the skin and with approximately 1.5 curies of emanation, it gives the standard erythema dose at 6,000 mc. hours.

From the measurements obtained, the standard erythema dose was determined for the *x*-ray machine at 2.3 ma. hours when operated under the following conditions: 198 kv. (measured with ball sphere gap of 12.5 cm. diameter); 3 ma.; .5 mm. copper filter; 30 cm. focus skin distance; 10 × 15 cm. field.

The radium pack, under these conditions, gives 17 per cent of the skin dose at 10 cm. depth, while the *x*-ray machine gives 29 per cent of the skin dose at 10 cm. depth; with 2.55 gr. of radium, the erythema could be produced in the same time as with the *x*-ray machine.

The percentage depth dose obtained from the radium pack at so short a distance shows an apparent advantage over the *x*-ray, and is dependent upon three main factors:

(*a*) The hardness of the rays.
(*b*) The large radiating surface.
(*c*) The wide angle of the ray cone.

In order to compare radium and *x*-rays under similar conditions, these factors must be made comparable.

1. The radium must be so disposed that an area, comparable to the radiating surface on an *x*-ray target, is obtained.

2. The distance must be the same or approximately the same.

3. The angle of the cones must approximate.

The shortest distance in which we could measure the intensity of the *x*-rays was 20 cm. from the target, and it was, therefore, necessary to measure the radium at the same distance. At this distance, the small ionization chamber attached to the gold-leaf electroscope was not sufficiently sensitive for the radium measurements. Furthermore, as before referred to, the distance and protection were not adequate. It was, therefore, necessary to build a special measuring apparatus for this purpose. It differs from the first apparatus only in details. The capacity of the ionization chamber was increased to 10 c.c. The insulated wire was 14 ft., and the measuring apparatus was a quadrant electrometer protected by a heavy lead block, 8 cm. in thickness. The results of the comparative measurements are shown in the table.

In order to determine whether the difference in size of the ionization chambers would affect the values of the percentage depth doses obtained, *x*-ray measurements were made with this chamber at 50 cm. distance (the device was too sensitive for *x*-ray measurements at 20 cm.). Measured at 50 cm., the value with the *large chamber*

was 33.5 per cent, and with the *small chamber*, 34 per cent, showing a close agreement of the values obtained with the two chambers.

From the table, it can be seen that at 20 cm., *x*-rays at 200 kv. with a circular field of 13.5 cm. diameter, taking the focal spot of the target as .2 cm.^{2} filtered through .5 mm. of copper plus 2 mm. paper, gives 24 per cent of the surface dose at 10 cm. of depth, and that radium at a distance of 20 cm., with a field not larger than 25 × 25 cm., with a surface of 0.1 cm.^{2} filtered through 2 mm. of brass plus 2 mm. of rubber, gives 26 per cent of the surface dose at 10 cm. of depth.

DEPTH DOSE, 10 CM. DEEP AT 20 CM. DISTANCE, RADIATING SURFACE OF SKIN

Field	Calculated maximum dose 44 per cent	*X*-rays-200 kv.	Radium		
		Circ. 13.5 cm. d.	25 × 25 cm.		
		3 ma.	Equivalent to 64 gr.		
Radiating surface		Target 0.2 cm.^{2}	0.1 cm.^{2}	3 × 4 cm.	6.5 × 7 cm.
Filter		.5 mm. Cu + 2 mm. paper	2 mm. brass + 2 mm. rubber		
Depth dose		24 per cent	26 per cent	30 per cent	34 per cent

In comparing these figures, it may be noted that the surface of the radium is less than the target surface taken, but that the circular field, 13.5, which was the largest obtainable with the *x*-ray tube at 20 cm., is less than the 25 × 25 cm. field for the radium.

With regard to the surface distribution of the two sources of radiation at a distance of 20 cm., the advantage in surface of the *x*-ray is not important. The difference in size of field which is in favor of the radium is also not of great importance; therefore, we may assume that the conditions are, for practical purposes, comparable. The factor of error in the results obtained may be as much as one or two units, but it is assumed that the difference between the two percentages obtained is at least one unit, which is, in reality, not less than 4 per cent in favor of the radium, and probably 10 per cent.

Let us assume that the extreme possibility is 15 per cent. Under the conditions stated, the advantages in favor of radium over the *x*-ray at 200,000 volts must be attributed to the shorter wave-lengths of the gamma rays of radium, and we may now ask ourselves whether there will be great advantage in increasing the kilovoltage of the *x*-ray system, for the purpose of obtaining harder rays, much beyond the 200 kv. now available. It has been claimed that the greater portion of the improvement to be obtained by raising the voltage is accomplished at approximately 250 kv., and from a consideration of these figures it would seem as though that was a reasonable conclusion. Certainly, if the minimum figures shown by these measurements are correct, it seems probable that we should be contented with *x*-rays of the wave-length producible at approximately 250,000 volts. This conclusion is entirely beside the question of whether voltage should be raised for the purpose of developing more energy from the *x*-ray tube. By noting on the table that when the radium surface is increased to 3 × 4 cm., the depth dose at 10 cm. is 30 per cent that of the skin surface, and that when it is increased to 6.5 × 7 cm., the percentage depth dose is 34 per cent, it becomes clear that the greater part of the performance of the radium pack is due to the large radiating surface.

As at present constructed, the large surface of distribution in the present form of radium pack involves the disadvantage of a wide angle cone, which means that a very considerable volume of tissue is necessarily radiated even when the lesion to be treated is small, and that the rapid spreading of the rays materially reduces the percentage depth dose. In this particular, the greater distances available in *x*-ray technique are a marked advantage in favor of the *x*-ray, the rays coming from

the target approximating more and more to parallel as the distance increases.

Preliminary studies indicate that a better depth dose may be obtained with a better distribution of the energy by construction of a special device. The mechanical details of this arrangement are not definitely determined, but it may be stated that by taking advantage of the principle of crossfire and proper lead screening, an arrangement can be made by which, instead of projecting a cone into the tissue, a cylinder with practically parallel sides may be achieved. Furthermore, by this arrangement a concentration in the center may be obtained. Even distribution is achieved by rotation.

By means of the arrangement which we are now studying, automatic crossfire is achieved. A somewhat larger area of skin is utilized than in the form of pack commonly used, and an actual concentration in the center of radiation is accomplished by crossfire. The work is still in progress, but sufficiently far advanced to show that an improved arrangement is possible both in distribution and percentage depth dose.

Photographic films show that whereas, with a pack of present construction, at a depth of 5 cm., 30 per cent of the surface dose was measured, with the new construction, 60 per cent is attained. Thus for a given area, at a given depth, an improvement may be obtained which would render the efficiency of radium twice that of the old arrangement.

In considering the relative advantages of radium and the *x*-ray for external radiation, it must be remembered that to compete quantitatively with present *x*-ray equipment, huge amounts of radium would be required, the cost of which would be prohibitive. The difficulty of obtaining adequate protection from such large amounts, even if available, would constitute an insurmountable obstacle.

Moderate amounts of radium in properly arranged packs will, in some instances, be found to meet special conditions better than *x*-rays, but these occasions are few. With the improvements which may be expected in the near future, the field of usefulness for the moderate-sized radium pack will be increased. The advantages of *x*-rays apply only to external radiation. In those cases where the growth can be reached, and radium or emanation of radium can be planted into the substance of the tumor, *x*-rays cannot displace radium. They can, however, be usefully combined with implantation, and the problems presented by certain lesions may be best met in this manner.

[DISCUSSION*

DR. VIOL. I wish to express my gratification after hearing the splendid paper of Dr. Gaylord, and the beautiful demonstration which Mr. Failla has given. The physicist stands in somewhat the position of a law interpreter, and perhaps, in some respects, the position of the minister, and I sometimes feel that radiologists make use of his services as some people do their religion; they are very attentive to the sermon on Sunday, but the application of the Sunday truths is often difficult on week days. So the radiologist, while appreciating the physicist's advice, finds it hard to make practical application.

The most important fact brought out by these papers is the confirmation which they bring of that statement by Kroenig and Friedrich, to the effect that the absorption in the tissue of the same quantity of radiant energy, whether *x*-ray or gamma ray, produces the same physiological reaction. This principle is one which the physicists have believed in for many years, but which the clinicians have not confirmed because of the lack of adequate measuring devices, and because of the inherently different modes of application of the *x*-rays and the radium rays. As Mr. Failla has pointed out, it is not possible to compare the effects of unscreened radium with those of *x*-rays and screened radium, since the beta rays, which come into play from the unscreened radium, produce such intense but superficial reactions.

Drs. Gaylord and Stenstroem, through their results, show what can be done by the proper use of good equipment, and Mr. Failla, by his detailed description, has brought out very clearly the difficult points which confront us in the apparatus used in the measurement of quantities of gamma and *x*-rays. There is no question that the measurement of the ionization produced by these different forms of radiant energy gives us the best means of measuring quantities of *x*-rays and gamma

* This discussion has reference to the preceding paper by Mr. Failla, as well as to the above.

rays; and in the future this method promises much in the control of dosage.

The physicist is an interpreter rather than a law-giver, and cannot, therefore, be held at fault if, through the desire for simplicity, wrong principles have been set up. To cite a case where the principle is biological, rather than physical, we may take the conclusion of Seitz and Wintz, who have stated that the variation in the resistance of carcinoma cells to the influence of *x*-rays varies so little that they have established as a lethal dose for carcinoma a dose representing approximately 100 to 110 per cent of the skin erythema dose for hard *x*-rays. This is admirable in its simplicity, but, unfortunately, the clinicians do not find that the application of such a dose of *x*-rays uniformly causes the regression of the malignant growth. Similarly, from the physical standpoint, you will recall the diagram shown on the screen by Dr. Schmitz yesterday. You will recall the beam of *x*-rays passed through the pelvic area from the front, and another from the back, together with the figures at the side indicating the fraction of an erythema dose produced at different points throughout the body. These figures, it must be remembered, actually represent the intensity of radiation down the central axis of the beam, and consequently, apply really only to a line drawn through the body, since the intensity in the beam falls off in an appreciable degree as one passes away from the central axis of the beam. Hence, while data of this sort might seem to indicate that the entire pelvic cavity was everywhere receiving a full erythema dose, the fact is, that away from the axis of the crossing beams, the intensity is somewhat reduced. Points such as this must be understood by the clinician; otherwise, he may wrongly interpret physical findings.

The matter of dosage, of course, is a point of greatest moment to the radiologist, who in this matter is continually between Scylla and Charybdis. Not enough radiation, and a curative result cannot be expected. Over-radiation, and a bad result also is likely. Perthes, in a paper recently published in the French *Journal de Radiologie*, particularly calls attention to the danger of over-dosage; and I was glad to hear Dr. Lee call attention to the danger of overdosage in his paper. Perthes tried to take into account the various factors coming into play when radiation is used to influence a growth, and considers three points particularly: First, the resistance of the tumor; second, the resistance of immediately adjacent normal tissues; third, the general bodily resistance of the individual. In the treatment of such a condition by radiation, Perthes believes that such a dose of rays must be used as will cause the retrogression of the tumor without devitalizing the adjacent normal tissues. If the patient's general condition will tolerate this amount of radiation, and the tumor can be caused to retrogress under such conditions, the progress should be favorable. If, however, the destruction of the tumor involves the devitalization of adjacent normal tissues, or there is too great a systemic reaction, then the outlook is unfavorable, since in the first instance it is unlikely that the local growth will be destroyed. More probably it will grow rapidly, and if the patient's general condition is poor, the end is soon.

The physical measurement of dosage by the methods which have been described in the papers of Drs. Gaylord and Stenstroem and Mr. Failla, are of the utmost importance in this important matter of dosage. This is particularly true for the *x*-ray, since different installations will have their own output which cannot be gauged except by measurement, while radium always gives off a definite kind of radiation whose quantity is proportional to the amount of radium.

In closing, I would heartily urge the members of this society to study carefully these physical papers when they are published, because I feel that they are of first importance, and probably are too technical for the radiologist to grasp completely, as they have been presented on the platform today.

Dr. Schmitz. I have been very much interested in the presentation of these papers and in their discussion by Dr. Viol. It has seemed to me that, in reading clinical observations, it makes quite a difference of what wavelength the radiation is. We have been very fortunate, in Chicago, in knowing the intensity we can obtain with the *x*-rays and gamma rays. We have worked with 200 kv. and with the gamma rays and if we compare the result obtained with the 200 kv. with radium, we make the following observation: With 100 kv. rays and radium it usually took the patient six weeks to get over the systemic reaction, and also from six to eight weeks, before any local reaction occurred, so that we could call the patient negative. With the 200 kv. the patient is negative in three weeks, and the systemic reaction is very much less than with the 100 kv. It seems to me that with the shorter wavelength, the effect is better on the tissues, and that the ideal would be, if we could, to produce with the *x*-ray the effect of the gamma ray of radium. It has taken us two years to estimate the exact dose for the skin. I am not saying that the erythema dose for different types of skin may produce entirely different reactions.

Therefore, we thought it would be better if we had some biologic reaction which would be the same as for the skin dose, and for that purpose we chose a loss of hair following radium application—the pubic hair. Therefore, we feel that we have a skin dose that requires only one interpretation, and not the interpretations that various people may give to the skin dose. With the established factors, we know just when they get this epilating dose. With a .5 mm. filter, a field 20 cm. square and 5 ma. to the tube, we gave this treatment. When the new machine arrived, we had two electroscopes, and also an electroscope which I had constructed at the University of Chicago, very much like that of Dr. Gaylord at Buffalo. With these three instruments we constantly have an epilating skin dose, so that when two instruments get out of order, there is still one left. We then began to work with the 200 kv. *x*-rays, and it was an easy thing to determine with the higher voltage what we should use to obtain the skin dose. Dr. Bachem thought forty min. would do, but I insisted upon seventy min. He wanted to know why I insisted on seventy min., and I told him if he would take my electroscope he would see that the time duration in minutes would be seventy. He doubted this, and then we found that his electroscope in transit had become very imperfect. We had it standardized again, and then it bore this out. In the table presented yesterday where the curves were given, I did not say this would give the intensity curve at all. I spoke of the intensities which were obtained in the *x*-ray beam. With the large beams which we use, from 20 to 25 cm. square, the difference is 5 per cent; hence, in the actual interpretation of these *x*-ray intensities, we are absolutely safe in using these intensities, and stating that the intensity is almost homogeneous with the tissue in which the cancer element, sensitive to radiation, is contained. That is why I do not go to the laborious work of determining for each and every centimeter of tissue. Of course we know that exists.

Dr. Stenstroem. First, I wish to point out, in order to avoid misunderstanding, that Mr. Failla's measurements ought not to be confused with our measurements. Mr. Failla compared the intensity from *x*-rays and from beta rays while we compared the intensity from *x*-rays and from gamma rays. When we are using the radium externally we are not using the beta rays at all. They are completely absorbed by the filter. It is not surprising that Mr. Failla did not get the same results with *x*-rays as with beta rays. One could not expect that. There are great difficulties in measuring beta rays with an ionization chamber, because the chamber cannot be made smaller than 1 c.c. capacity. If we are using a tube about 1 cm. long, and intend to measure the distribution of beta rays around it, the intensity will be so different in different parts of the chamber, that the measurements will not give us the true distribution.

As to Dr. Schmitz's remarks: I am surprised to hear about Dr. Schmitz's experience concerning the different reactions of patients toward different kinds of *x*-rays and gamma rays. At the State Institute in Buffalo our experience has been quite different. The reaction has been about the same for radium and *x*-rays at 200 and at 140 kv. When such comparisons are made, the amount of radiation must be measured with the right kind of an ionization chamber (built from organic substances and graphite). Correction for leakage must always be made when an ionization chamber is used for such measurements, and one must be quite familiar with these methods in order to get correct results.

We physicists are not trying to give you any more physical foundation than is absolutely necessary for correct treatment. As Dr. Viol pointed out, you can easily burn a patient inside the body without damaging the skin, if you are using "crossfire." If you are using the same voltage, milliamperage, focus-skin distance, filter, and size of field, for the treatment with your machine, as another doctor with another machine, you may burn your patient, or give him too small a dose, though the other doctor gave just the right dose. If you, however, give your patient the same amount of radiation on the skin and inside the body, measured in an accurate way by the ionization method as the other doctor, you, too, will give the right dose, and can be sure of not burning your patient, regardless of what kind of a machine you are using.

Dr. Gaylord (closing discussion). I had hoped that the simple facts brought out by our paper would not be obscured by our discussion. I desire to emphasize that our practical use of ionization methods has enabled us to determine the erythema dose by measurement of an unknown system for the production of *x*-rays.

At Atlantic City, I reported our first success in the use of this method. Dr. F. C. Wood remarked in his discussion of my talk, that he thought Dr. Gaylord and his associates had been very courageous, and extremely lucky.

In our paper, I pointed out that we have again done this with another unknown system and have determined with accuracy the erythema dose by comparing the energy from the

tube with the radium pack by means of measurements with the ionization chamber.

We are about to install another new machine in Buffalo, and we shall again rely upon this method. In both these instances we began the treatment of patients and had treated a number before we saw the erythema.

The improvements in *x*-ray equipment are, of course, important; but to the radiologist, they are not nearly so important as a physical basis of measurement. If in Buffalo, we were asked which we would most willingly give up, I would say that we should forego the improved apparatus and retain the methods of measurement. These methods of measurement have been used in the United States with radium for some time past. An accurate physical basis of measurement which will enable us to repeat with accuracy both the amount and distribution of radiation at depth is essential before we can even discuss biological effects. In the past, we never quite knew what we were doing, and hence a great deal of loose speculation has resulted as to the effects of radiation upon the tissues.

The purpose of our paper was to emphasize not alone the accuracy of these methods, but to show that by them we can compare radium and *x*-rays, and should be able within the limitation of each to use them interchangeably, or to select those fields for which each is especially suited.

MR. FAILLA (closing discussion). I am afraid Dr. Stenstroem misunderstood my remarks concerning the reliability of ionization measurements. In my paper I discussed ionization measurements in general, and therefore my remarks did not necessarily apply to Dr. Stenstroem's work. I have compared *x*-ray and gamma ray doses myself and have found them in close agreement.

RESULTS AND TECHNIQUE IN THE TREATMENT OF CARCINOMA OF THE BREAST BY RADIATION*

BY BURTON J. LEE, M.D.

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AS a part of the organized effort at the Memorial Hospital, which has been carried on for several years, to study and treat malignant disease in its many varied phases, a breast service was organized in 1919, to concentrate under a single head the work in this field. It has been my privilege to be responsible for this service, and the present paper presents a brief summary of the technique employed and the results accomplished up to the present time.

The cases under report were admitted to the hospital in the years 1918, 1919 and 1920, and none of our cases of the last year and a half have been included. We believe that too often radiation is thrown into disrepute as a therapeutic agent by over-enthusiastic reports of brilliant recent results. Certainly, any form of treatment applied to cancerous disease must stand the test of considerable time to determine its real value, and radiation is no exception to this rule. Further, a record of the exact status of the case at the time of admission, with continuous notes of observation and treatment, are useful, if one is to estimate what really has been accomplished.

TECHNIQUE

X-Ray Treatment. There has been an evolution in the *x*-ray treatment of breast cases during the past few years at the Memorial Hospital. Recently, and up to the present time, all treatments have been given by the ordinary type of *x*-ray machine, delivering a peak voltage of approximately 90,000. Some years ago, the exposures were three to four minutes each, with a spark gap of 8 in., and a focal distance of 8 or 9 in., using 4 ma. current and 4 mm. of aluminum filtration. These exposures were given at varying intervals, usually four or five weeks apart. Eventually, definite telangiectases appeared in the radiated skin, and, in one or two instances, definite epitheliomata developed in the site of the overradiated area.

Three or four years ago, the time period was lengthened to six or seven minutes

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with a spark gap of 10 in. and a 10-in. focal distance, with intervals between the treatments of about five or six weeks, the number of treatments given over any one area usually not being more than three or four. This type of radiation has undoubtedly a more penetrating effect and the skin becomes definitely pigmented, but up to the present time only a few cases have shown marked telangiectasis.

Within the last year, stimulated probably by the recent work with the high-voltage machines, the time period has been increased from fifteen to eighteen minutes and longer, with a 10-in. spark gap and a 12- to 15-in. focus skin distance, using 4 ma. of current and 4 or 5 mm. of aluminum filtration. This technique has been used where the tumor of the breast was of considerable thickness and a definite radiation of the deeper tissues was desired. Where superficial, subcutaneous nodules were being cared for, the older type of radiation with five- or seven-minute exposures has been the usual procedure.

We have used the *x*-ray routinely for pre-operative treatment before a radical operation, giving one complete cycle of about four treatments over the whole breast and axillary and supraclavicular regions. Following operation, after the wound has completely healed, usually in two or three weeks, it has been our practice to give two complete *x*-ray cycles covering the whole breast and lymphatic drainage areas. We feel certain that unless a very definite and pronounced erythema of the skin is produced following *x*-radiation, a tumor lying in the deeper portion of the breast has not been sufficiently radiated.

Treatment by Radium. Treatment of breast carcinomata by radium has been applied by one of five separate methods of application or various combinations of them, namely: pack, tray, dental mould, insertion of bare emanation tubes, and the insertion of platinum needles containing radium emanation.

The pack has been frequently described by various members of the Memorial Hospital Staff, and I need not go into many details concerning its construction. Suffice it to say it provides a filtration of ½ mm. of silver and 2 mm. of brass, and for ordinary breast tumors and axillary nodes it is placed at a distance of 6 cm., maintained by a wooden block beneath the pack, giving a dosage of 8,000 to 9,000 mc. hours over an area of approximately 70 sq. cm. This is particularly of use, we believe, in breast carcinomata involving the chest wall and sternum, small tumors of the breast itself, and over the axillary and supraclavicular regions, particularly if the nodes are deeply placed. We make use of it also in metastases over bones with a similar dosage, and in spinal metastases at a distance of 10 cm., we give approximately 16,000 to 18,000 mc. hours of treatment, with considerable relief of pain in some instances.

The tray is a smaller external applicator giving the same filtration, but used at a distance of 3 cm. for more superficial and localized nodules, the dosage reaching 2,500 to 3,000 mc. hours. We have found, as our work has developed, that we are using the tray less and less, as the larger drainage areas, such as the axillary and supraclavicular regions, often contain deeply placed nodes which are more efficiently radiated by the pack than the tray.

The dental mould, carrying silver filtrated radium, we have used in a number of cases of Paget's disease of the nipple with a very limited lesion present, and, in one or two instances, in small inoperable carcinomata placed exactly at the junction of the chest wall with the breast, the mould fitting nicely over the carcinomatous mass. Radiation by this method has recently given some very satisfactory results.

The insertion of emanation bare tubes by means of a long needle carrying a plunger is being used very extensively in primary inoperable tumors, giving a dosage of approximately 1 mc. per c.c. of tumor tissue. Caution should be exercised that the bare tube is not placed nearer to the skin than 1 cm.; otherwise it may cause an area of ulceration. Also, one should be careful to avoid placing the bare tube directly against a rib or rib cartilage, because of the possibility of injuring the periosteum. The general tendency in earlier years was to give repeated treatment by bare tubes in small doses.

The present technique consists in carefully estimating the exact size of the tumor at the time of the original visit of the patient; and an effort is made at the time of the primary treatment to accomplish a complete radiation of the tumor, always, however, after an *x*-ray cycle has been given. In some cases now under observation, we believe no second introduction of bare tubes will be necessary in the breast tumor itself.

Localized subcutaneous nodules in the chest wall may also be cared for by the implantation of small bare tubes of 1 mc. strength beneath the nodule, but they may be equally well or even better treated by *x*-radiation. The introduction of bare tubes into axillary nodes has turned out to be a difficult matter, for without opening the axilla, one cannot accurately localize the nodes at the time of introduction, and so a satisfactory implantation may be impossible. We frequently find, on opening the axilla in the endeavor to isolate nodes, that it is easier to dissect out fat and nodes themselves than to attempt to introduce radium into the separate nodes. More recently, we are placing bare tubes along the inferior posterior aspect of the pectoral muscle, believing that a reasonably efficient radiation of the axilla may be accomplished by this means. Bare tubes should never be placed nearer than 1 cm. to the branches of the brachial plexus, as an intractable case of neuritis may ensue. In general, we have found the management of axillary nodes one of the big problems in the treatment of breast carcinomata by radiation, and we feel that our present means of attack is not wholly satisfactory.

Within the last eight months we have been using the platinum needle, giving a filtration of $\frac{4}{10}$ mm. of platinum, carrying radium emanation tubes of about 60 to 70 mc., giving a dosage of 50 mc. hours per c.c. The theoretical difference between this needle and bare tubes is that no foreign body is left in the tumor and a less accurate implantation is required. We have had some recent interesting regressions in tumors treated with this method, but have not sufficient data at present to make a satisfactory report upon the results obtained.

Pleural and mediastinal involvements have so far not been completely radiated, for the necessity of radiating normal tissue and the length of time required have made it difficult to accomplish. We are hoping that a treatment of the chest areas with our new high-voltage machine may give more satisfactory results in the pleural and mediastinal areas.

RESULTS IN VARIOUS GROUPS

Primary Operable Carcinoma of the Breast. Following radiation of a breast carcinoma, a definite fibrosis occurs in and about the tumor, but the mass present may not contain any definite living tumor cells. In a case which has shown considerable regression, if radiation is persisted in, and especially if bare-tube insertion or the platinum needle is employed several times, one is very apt to break down connective tissue in and about the tumor, causing an intractable ulceration. It is much wiser to avoid overradiation of such cases, being satisfied with a fair rather than a perfect result.

The average routine case in this group is given a pre-operative *x*-ray cycle, followed three to four days afterwards by a complete radical operation, using the Willy-Meyer-Halstead technique, both muscles being removed. A very long oblique incision is made, running 2 in. below the costal margin, and this usually enables complete closure of the wound. Very careful and wide dissection of fat and fascia underlying skin flaps is made. We have had but very few instances of skin recurrence in the clinic in the past three years, so that we feel that this type of operation without a wide sacrifice of skin, is justifiable. When the wound is completely healed, two or three weeks following operation, a complete postoperative cycle of *x*-rays is given. The case is followed routinely in the breast clinic indefinitely, month by month, and treatment is given as indicated.

Exceptional cases occurring in the primary operable group are the women at or above seventy years of age, which special group we have determined to follow through, entirely on the basis of treatment by radiation. Although some older women

are perfectly good operative risks, we feel that this is a justifiable procedure in these cases, and we are following this limited group with a considerable degree of interest. Further, we believe that a definite obligation rests upon Memorial Hospital to develop data of this sort, and we believe that it is possible without added risk to our patients. We have had some very interesting and satisfactory results to date, covering a period, in some cases, of two years. The procedure for such cases is *x*-ray externally, and insertion of bare tubes into the tumor and axillary masses. We do not, however, feel justified in making a further report at present on these cases.

Primary Inoperable Carcinoma of the Breast. This constitutes one of our large groups, and certainly one in which, without radiation, a practically hopeless result must be expected by the surgeon in charge of the case. Of the 83 cases occurring in this group in the period covered in the present report, 26 were very advanced, the average duration of life after treatment approximating four months, with a total average duration of two years and 9.2 months. All the cases in this group are dead. Of the 57 more favorable ones which might reasonably be treated with some hope of success, 25 are alive at the writing of this report of those doing well. Of these, 12 are doing badly, and 13 are doing well. The average duration of life after treatment was two years and 3.1 months, the longest duration after treatment being four years and the shortest, one year and 5 months.

Recurrent Inoperable Carcinoma of the Breast. This is our largest group in which the surgeon must look to the radiologist for definite help, for treatment by radiation offers practically the only hope of checking the disease or curing the patient. In the years 1918, 1919 and 1920, only six patients presented themselves to the hospital whom we felt justified in classifying as recurrent operable carcinomata of the breast.

In the treatment of these cases, *x*-radiation has been by far the agent most often employed, and, the radium pack or radium bare tubes have been used in well localized, sharply defined recurrent masses. In comparing our series of recurrent cases, covering three years, with those of another New York Hospital where no radiation was used after operation or for recurrence, we find that our period of life following recurrence is three times as long as theirs. We feel, therefore, that the treatment of recurrent cases by radiation gives, without doubt, a marked prolongation of life. In our group of recurrent inoperable cases, we have felt it wise to make a subdivision between the really advanced cases and those in which reasonable hope of improvement might be expected from radiation. Excluding the very advanced cases, we have had 124 in the recurrent inoperable class, 31 of which are alive, some of them doing well. We therefore are greatly encouraged in the treatment of these cases by radiation.

Propbylactic Cases Reported for Treatment after Radical Removal of the Breast for Carcinoma. We have routinely given a pre-operative *x*-ray cycle for the past four or five years. We believe that it is of definite service, and that it does not materially interfere with wound healing. Sufficient evidence has not accumulated up to date to determine whether or not the pre-operative cycle prevents or delays a possible recurrence, but we believe that it may do both. A later study, comparing a large group of cases in which a pre-operative cycle was not used with one at Memorial Hospital in which it was, may furnish some data to settle the question of usefulness.

Concerning the postoperative cycle, we feel certain that it is efficient and that it has given marked results in cases where it has been employed, for we know it lengthens the time between the operation and recurrence. We believe, too, that it may entirely prevent a recurrence, if properly planned and administered, and delay the rate of growth when recurrence has already occurred.

Pathology. As to the pathology of cases under our care, we have made an earnest effort to obtain microscopic sections of as many cases as possible in the clinic, but at present we have been able to obtain this information in only about 40 per cent of the cases. Up to the present it has been

difficult to correlate the histological picture with the clinical behavior of the disease, although certain anatomical types follow a more or less fixed clinical course, but we hope that by observation and study we may reach a more reasonable basis for therapy for the various anatomical varieties of breast carcinoma.

CONCLUSIONS

All in all, the outlook in the treatment of carcinomata of the breast by radiation is a most encouraging one. We feel that in no case of mammary cancer treated by surgery can the proper use of *x*-radiation be discarded. Radiation, properly administered, is the most effective aid in the care of carcinoma of the breast surgically treated; and in every surgical clinic a pre-operative and postoperative cycle should be employed if best results are to be obtained.

As to the treatment of primary inoperable and recurrent cases: We feel that our best method at present is external radiation by *x*-ray, with a fifteen-minute exposure, 10-in. spark gap, and 12-in. focal distance, with 4 mm. aluminum filtration, and 4 ma. of current, followed by an implantation of radium bare tubes into the growth, giving a complete dose at the first sitting. We are greatly encouraged at the present outlook.

We know that surgery has something very definite to offer for the relief of carcinoma of the breast, but we also feel that a more careful follow-up of cases in the surgical field may reveal a much poorer percentage of five-year cures than is generally believed. Our own conviction is, that of 100 cases treated surgically, 15 to 25 per cent may be expected to be alive at the end of five years.

With such a discouraging outlook afforded by surgery, we feel that the addition of radiation to the treatment of this terrible disease should be followed in a most careful and systematic manner, the radiologist and the surgeon working together to solve the therapy of the disease.

DISCUSSION

DR. BURNAM. I notice the essayist did not mention the differences in the radiosensibility of the scirrhous type, the medullary type and the types of breast cancer. I believe there are other marked differences, depending on the histological structure. Small, round-cell, scirrhous tumors in old women are difficult to affect. It is well to remember that patients with microscopical evidence of cancer can live for years in good health. I recently saw a woman who had a small recurrent nodule in the scar of a breast removal of twenty years before.

We have had splendid results in bone metastases, particularly of the skull and spine. As these are the occasion of pain and disability, the relief of such metastases, even where general cure is impossible, may be of great value. I feel that radium offers a means of widely extending the surgical operation locally, and of taking care of some metastases. One case of adenocarcinoma of the breast (medullary type), which I have had under observation more than two years, seems almost as radiosensible as a sarcoma. Some other cases have stood radiation that squamous cell epithelioma would have yielded to, without being destroyed.

DR. GAYLORD. I did not hear all of Dr. Lee's address, but it seems to me that with regard to carcinoma of the breast, there is one definite problem, and that is whether we may substitute radium for surgery.

We have treated between 30 and 40 cases of early operable carcinoma with radium and *x*-ray combined.

I had the pleasure recently of showing 6 such cases to Dr. F. Finney, when he visited the Institute. Distinct evidence of carcinoma had disappeared, only small indurations being left. Dr. Finney was of the opinion that these cases should not be operated upon, but should be observed for a period of years for the purpose of determining the value of radiation in early carcinoma.

At the State Institute, where we maintain a diagnosis service for the surgeons of the state, we have witnessed in the last ten years a great change in the character of the specimens sent in. When the service started, 90 per cent of the specimens were carcinoma; today, this per cent is only 28; showing that surgeons are removing suspicious lesions much earlier than previously, and are also sending us earlier cases than before.

DR. PFAHLER. We have one patient alive eight years after a definite mediastinal involvement; another one lived six years and ultimately died of the disease. We have several others who have lived a shorter time.

DR. LEE (closing discussion). In the first place, I think the surgical results to date, so far as I see the cases, are not as good as the majority of us believe. I followed through our

cases at the Memorial Hospital for five years with and without metastases and find that the surgical results were much poorer than I had anticipated they would be.

Another point: A case that is clinically and primarily an operable carcinoma may not be at all a suitable case for operation. For instance, a young woman of twenty-seven, pregnant two months, with a rapidly growing tumor involving the whole breast, is not a case for operation. It is much better left alone, or the uterus emptied and the area radiated. I recently saw a case of this very type. Some men wanted to operate on this woman, but I advised strongly against it. We have had several cases at the breast clinic at the Memorial Hospital, with supraclavicular nodes as big as a fist, which we classified as inoperable. They have gone outside and consulted another surgeon, who has performed the usual radical breast amputation, and in six months have come back with nodes as big as ever. I think many cases should be treated surgically; for instance, 75 per cent of the operable cases at the Memorial Hospital, in the last five years.

As to pre-operative radiation, we do not feel that at present we have real evidence for or against it. We believe that ultimately a large series of cases may be compared with cases that have not had pre-operative *x*-ray; and in this way we may obtain some idea of the result that may be attained.

AN AUTOMATIC SWITCH FOR BUCKY DIAPHRAGMS

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THE dissatisfaction with the devices ordinarily used to indicate that the grid of a Bucky diaphragm is moving, has been indicated several times by the published description of various substitutes. All the while, it seemed that something which would automatically make the exposure while the grid would be moving, and at the same time insure against the appearance of the "corduroy" markings, would satisfy the requirements completely. For that reason, the method which I have used in the *x*-ray department of St. Bartholomew's Clinic and Hospital since April, 1922, seems to merit description.

It consists, as will be seen in the accompanying sketch, of a sliding contact switch with which the "make" occurs after the grid has started to move, and which will break the circuit before the grid has again come to rest.

The fixed pole of the switch consists of a metal plate counter-sunk into a block of fiber or other insulating material so that the surfaces of the conductor and its insulating base are flush with each other, and so that the other pole of the switch may travel across the block without interference that will affect the motion of the grid, to which it is attached by a fiber arm. The length of the plate should be such that the arc described across it by the moving contact point will *not* exactly equal the distance between any two strips of the grid, so insuring that the metal strips are not in the same relative positions to the fiber at the beginning and end of the exposure. Also, the plate should be so placed in the block that contact is made approximately during the middle two quarters of the grid's excursion.

A binding post is fixed to the metal plate at such a place that it will be entirely clear of the movable pole.

The movable pole consists of a short metal bar, one end of which is fastened to the insulating block beneath the middle of the metal plate, and in such position that its free end may describe an arc across the fixed pole. Extending at a right angle from the free end of this bar is a screw with a rounded head. It is locked to the swinging arm at a length so as to make contact when it slides across the metal plate. When at rest, however, this screw-head rests on the insulating block. A second binding post is fastened to a convenient place on the swinging bar, near its fixed end. This bar is also connected to the middle of one end of the grid by a fiber bar, so that when the grid moves, the free arm of the switch is driven back and forth across the fixed plate.

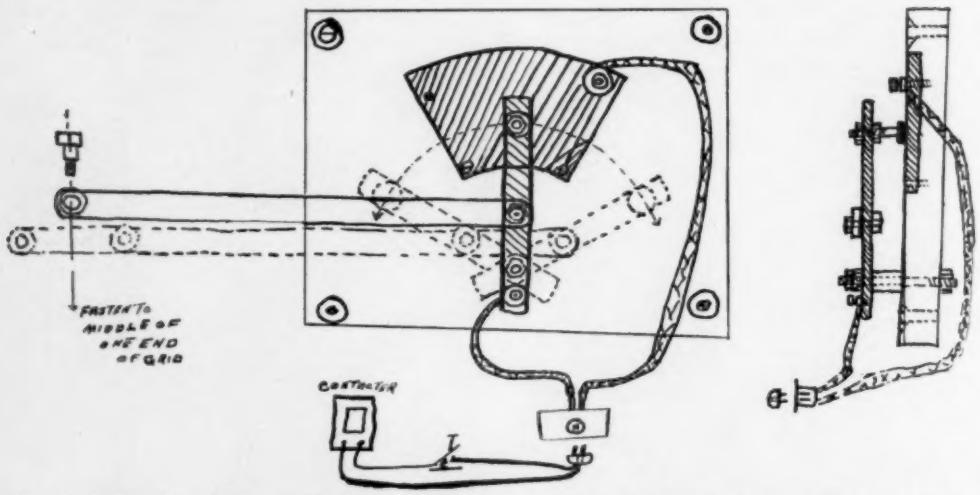
The switch should be mounted at one end of the Bucky diaphragm and inside the frame by screws through the block near its corners, and with the back of the block away from the grid. When the top of the "Bucky" is replaced, the switch is entirely enclosed.

The leads from the two binding posts go to an attachment receptacle of the flush wall type. This should be located so as to open on the side of the Bucky away from that in which the cassettes are placed. An extension cord, when plugged into this receptacle, leads to the solenoid of a remote control contactor, such as is used on, or can be adapted to, any *x*-ray machine. The only reason for not taking these leads directly to the primary of the high tension transformer is that the arcing in making and breaking of heavy currents would probably soon destroy the sliding contacts. Somewhere in the leads, between the Bucky diaphragm and the contactor, a spring foot-switch should be placed in series with the sliding contact switch. As this will have to be closed when making the exposure, it will, when open, permit the resetting of the grid without intentionally opening the circuit elsewhere.

This device can be built in the laboratory, and, as it is complete in itself and in no way interferes with other signal devices, it need not be used unless so desired. The length of exposure is entirely dependent on the speed of the grid, and if used, the exposure must be made while the grid is moving.

The most serious objection that can be offered to the use of this arrangement is, that it places grounded metal beneath the patient. However, since Bucky exposures are made with the tube at a greater than average distance from the film, and thus at a greater distance from the patient, perfect safety would generally be insured. So it seems that under the circumstances of its special purpose, the added convenience afforded by this device would permit us to use it, even though grounded metal beneath the patient is to be ordinarily avoided.

I wish to acknowledge the assistance given by Mr. J. M. Blake, the chief engineer at St. Bartholomew's, and to thank him for building the switch that I am now using.



The shaded portions indicate the conductors. The positions of the swinging arm before and after exposure are indicated by the broken lines.

A NOTE ON THE USE OF THE BUCKY-POTTER DIAPHRAGM WITH THE FLUOROSCOPE

BY WALTER C. ALVAREZ, M.D.

SAN FRANCISCO, CALIFORNIA

WHEN the great efficiency of the Bucky-Potter diaphragm became apparent two years ago, a few manufacturers supplied grids for use on fluoroscopes. I tried one for a while and then gave it up because the shadows of the lead strips bothered me and cut out so much of the light.

A few months ago there appeared the paper of Wilsey,[1] who showed that the efficiency of these diaphragms depends largely on the closeness of the photographic plate to the grid. It immediately occurred to me that a high degree of efficiency in the fluoroscope might be obtained by removing the calcium tungstate screen from its position next to the lead glass window, and fastening it closely to the convex surface of a grid placed just behind that window. This was done, and the screen surface was protected from dust and dripping barium by a thin cover of celluloid (a 14 × 17 film with its emulsion removed).

The results obtained have been most satisfactory, and I would not now think of parting with the apparatus. Even in stout people the abdominal organs show up much as they do in a good plate. Strange to say, the grid hardly shows at all. It is troublesome only when one is looking at the chest. Some light is, of course, cut out by the apparatus, but this loss is more than compensated for by the great increase in definition at the edges of the barium shadows. Furthermore, I find that I can use with advantage a much higher spark-gap than ever before. This gives better penetration in cases of stout people, without any of the fogging which formerly increased as fast as the voltage was raised.

The only objection I now have to the grid on the fluoroscope is that when paldating the abdomen one has to be so careful to keep the screen from rotating slightly on a vertical axis. Such rotation naturally shuts off almost all the light.

The more recent work of Wilsey[2] shows that an efficient grid can be made .16 in. deep with lead strips .01 in. thick and gaps .05 in. wide. It seems to me that the use of such a delicate grid, with the fluorescent screen closely applied, would bring the radioscope very close to perfection.

[1] WILSEY, R. B. The efficiency of the Bucky-diaphragm principle AM. J. ROENTGENOL., 1922, IX, 58.

[2] WILSEY, R. B. Some practical results with a Potter-Bucky diaphragm. AM. J. ROENTGENOL., 1922, IX, 441.

THE EFFECT OF THE WAR ON THE DEVELOPMENT OF ROENTGENOLOGY*

BY PRESTON M. HICKEY, A.B., M.D.

ANN ARBOR, MICHIGAN

IT IS always interesting to devote some attention to history. At the time history is being made, it is difficult to get any other viewpoint than that afforded in one's own immediate environment. It is necessary to wait for the perspective imparted by lapse of time to appreciate properly the various forces which are active, and to estimate their ultimate value to man.

If too much time is allowed to elapse before this historical study is made, the picture is frequently falsified by lack of knowledge of what actually took place. It is our belief that the popular historian is very rarely an accurate one.

It therefore seems to us timely to study some of the phases of roentgenology presented by the Great War, and to trace some of the after-influences as we now have the privilege of seeing them.

In 1914, the art of the roentgen rays was not quite past its second decade. Its applications had been limited principally to civil life. There had been no true opportunity to test the usefulness of the rays in military surgery, and comparatively little had been written about the uses which had been made; with the notable exception of the work published by the Surgeon-General's office, under the immediate direction of Colonel Ford, there was little literature to which one could turn.

There was, then, in 1914, presented a phase in medical history which was practically without precedent. There arose the opportunity for the medical profession to make use of a new discovery whose practical applications were of the utmost importance from a surgical and medical standpoint. When we think back and realize how quickly the new art was developed in its new applications from a military standpoint, we can again congratulate ourselves on belonging to probably the most progressive of all professions.

The French and English, although they attempted at once to make the most liberal use of the roentgen rays in their military hospitals, found themselves confronted with the great problem of supplies. In France, there was no time to develop factories; the lack of men, who were all needed in the army, the difficulty in obtaining materials, the suddenness with which the necessity arose, all combined to make the extensive use of the roentgen rays difficult. In order to supply the French army, practically every type of private *x*-ray outfit was taken over by the authorities and placed at the disposal of the military surgeons. The English were in a particularly unfortunate position, owing to their short-sighted policy of free trade. The English manufacturers of *x*-ray apparatus had never received any encouragement from their government, and, being placed in competition with German and French manufacturers, had, at the beginning of the war, not obtained any degree of manufacturing importance. Consequently, when the English authorities attempted to supply the demands of the English military surgeons, they found the greatest difficulty in manufacturing *x*-ray supplies. The English military hospitals were handicapped all through the war by the lack of *standardized* equipment. The wonderful way in which they "carried on," however, under such trying circumstances, is a matter of congratulation.

We feel proud of the way in which our American roentgenologists who were aiding the British in 1915 and 1916 did their part. Among the few names which I might mention are those of Walter Dodd, A. H. Pirie, and Percy Brown, whose fame will be lasting.

Even after it was apparent to the average reader of the daily newspaper that the United States would ultimately be drawn into the war, valuable time was apparently lost which could have been spent in preparation for the inevitable conflict. It was, perhaps, difficult for the

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

Surgeon-General's office, without authorization and appropriation from Congress, to take the initiative in planning and preparing for the *x*-ray needs of a great army.

However, when the decisive step was taken, the roentgenologists of the country, through their active cooperation, helped to make up for the time that had been lost, and by their enthusiasm and self-sacrificing patriotism performed their allotted tasks in a manner of which we can well be proud.

Very early in these preparations, it was definitely realized that only by standardization of methods of education and the adoption of uniform standardized types of apparatus could the work be successfully carried out. Fortunately, the manufacturers of this country had been favored by the government, so that they were in much better shape to undertake their tremendous task than had been their English and French brothers.

It would be useless, or perhaps I should say needless, to enumerate the various difficulties which were surmounted, as many of you are familiar, from your own experience, with the way in which the situation was handled. I think it can be said without exaggeration that no branch of the medical service of the army furnished more satisfactory and complete assistance than did the Department of Roentgenology. The American soldier, when wounded, and in need of rapid and accurate localization of bullet or shrapnel, was carefully and expeditiously cared for, and the American soldier, when ill, was taken care of by a medical department which always had the assistance, when desired, of a well-equipped *x*-ray laboratory.

It is a matter of congratulation to us, as members of this great specialty, to feel that the *x*-ray examinations, as demanded by military exigencies, were always available, and were completed in a manner which compared with any other department in the medical service.

From the fact that the *x*-ray work furnished to the army was highly satisfactory, there has resulted a great stimulus to *x*-ray work in general. It will be our pleasure to discuss for a few moments some of the various results which followed the war.

In the examination of the recruits for the Mexican campaign, in 1916, comparatively little was done with *x*-rays except as certain isolated and special cases might require.

With the beginning of the recruiting service for the Great War, there developed a conviction that the *x*-ray examination of the chest, somewhat superficial though it might be, in view of the thousands of men to be looked over, was an important factor in the weeding out of the physically unfit, and that with its use could be detected obscure pulmonary conditions which might become grossly exaggerated under the trying experiences of an active campaign. The work of Cole, Dunham, and others demonstrated most effectively that it was possible to examine quickly large numbers of men and make *x*-ray plates of their chests, and that the additional expense was amply justified by the saving to the government in suitably classifying those whose pulmonary pathology was important, if not always evident.

It is, perhaps, hard to realize the far-reaching effects of such a procedure in popularizing with the internist the routine *x*-ray examination of the chest. The army surgeon, recruited from the ranks of tne civilian practitioner, had not been in the habit of considering the roentgenograph of the chest as an important routine procedure. However, when, in the pursuance of his military duties, he found at his elbow a well-trained roentgenologist, with a comparatively well-equipped laboratory, he became accustomed to rely for the confirmation of his opinion on the intelligent interpretation of the pulmonary plates. When confronted with large numbers of cases of pneumonia, he began to realize that the well-interpreted plates had at least equal weight with a careful physical examination of the chest. One of the great factors in this change was the ease with which *x*-ray examinations could be obtained, without considering the cost in dollars and cents to the patient. Where previously he had found it necessary to consult with the patient as to whether the latter was financially able to afford the necessary *x*-ray examination, he

found all this changed, and that the simple writing of a request threw the financial burden on the government. If the internist were attached to a base hospital receiving hundreds of patients with the accompanying perplexing questions of diagnosis, he found that the simple request for an *x*-ray examination of the chest or of the gastro-intestinal tract would give him, not merely assistance in making up his mind as to the presence or absence of decided pathology, but that often the final word in the diagnosis would be furnished by the *X*-ray Department.

We think we can safely say that the average internist, during his military service, became rapidly educated to seek the assistance of the roentgenologist and the roentgen laboratory in a manner to which he was, indeed, before a stranger.

In looking over the statistics of *x*-ray departments in different parts of the country, we are struck by the great increase in the number of examinations which were made in the year 1918. This, we think, is largely accounted for by the fact that the returned military surgeons, when re-entering civil practice, continued their habit of seeking aid from the *x*-ray laboratories.

Not only did the military surgeon become rapidly accustomed to a more liberal employment of these examinations, but the returned soldier, when confronted by illness of himself or of his family, frequently suggested the use of *x*-rays to which he had become accustomed during his time of military service.

Hospital superintendents and members of hospital boards, from their experience with army necessities, have come, we think, to adopt a much more liberal policy than formerly with regard to the planning of *x*-ray laboratories in our various hospitals. Before the war, the favored place for the *x*-ray laboratory, according to the hospital superintendent's idea, was the basement, next door to the coal cellar or the laundry. A gradual improvement has been noticed in the location of *x*-ray laboratories, and a more liberal policy has been established with regard to the equipment of the same.

We believe also that this same increase of liberality has extended to the recompense for the work done. The salaries of roentgenologists have been increased, and in many cases the work has been placed upon a profit-sharing basis.

On account of the changed attitude of the profession and of the patient, *x*-ray laboratories in hospitals have been placed on a self-sustaining basis, and, in many instances, have become a distinct source of revenue to the finances of the hospital.

It is significant, also, to note that one of the requirements for an A class hospital is a well-equipped and properly manned *x*-ray laboratory.

The rapidly extended use of *x*-rays in war time introduced many physicians to the specialty, and after the war was over, there was observed a large increase in those who specialized in *x*-ray work. Many found places in the newly-developed clinics which rapidly arose in different parts of the country, and many opened offices, either as part-time or full-time roentgenologists. While some of these were only imperfectly fitted for their new specialty, the law of the survival of the fittest has either spurred them to diligent study or has weeded them out.

The influence of the war on the manufacturers of *x*-ray apparatus has also been very striking. On account of the large number of new roentgenologists, manufacturers have been kept quite busy, and the steady demand for their wares has enabled them to follow along lines of quantity production with well-standardized equipment. When one compares the American manufacturers with those abroad, he realizes that the former have fallen quickly in line with quantity production of standard quality, so characteristic of American manufacturers. At the present time one feels that money invested with any reputable American manufacturer will be exchanged for apparatus of a standard type.

In this hasty survey of the situation, it would be amiss not to mention the rapid development of so-called portable units since the war. Formerly our portable work was done with the dress-suit-case type of the high-frequency machine, without meters and without a precise technique. Formerly only the more simple types of

examinations were feasible; now with the modern portable machine, plates are obtained of a quality comparable with those made by a well-equipped laboratory.

It is quite fitting at this juncture to recall the painstaking, resourceful work which was done in the development of the portable outfit by our lamented friend, Professor Shearer. It is only when we place side by side the old model of the portable outfit with the present highly-developed model that we realize the developmental work which was done. Certainly none of the work, varied and extensive though it was, that Professor Shearer accomplished during his fruitful life was more productive of real practical results than the perfection of the bed-side unit.

On account of standardized methods in the army school and in army practice, the Coolidge tube has become even more popular and useful than before. Its wide popularity has resulted in a more uniform technique, which has steadfastly raised the general standard of excellence of plates. It is interesting to visit different laboratories and see the uniform excellence of work which is now being done, owing to a standardized technique.

A more liberal use of fluoroscopy in the removal of foreign bodies is also traceable to the army training. No longer is the hand or foot extensively mutilated in long-continued efforts to find a needle or a bullet. Operation under fluoroscopic control is now perfectly safe by the intermittent method, and results in easy removal, with a minimum laceration of the tissues.

The extensive use of the fluoroscope in the manipulation and control of fractures is also a step in roentgenologic progress.

Another outcome of the development of war activities has been the diminution in the size of machines. With the self-rectifying tube and the bed-side type of transformer, the internist is now able to do adequate fluoroscopy and still not encroach on valuable office space. In planning or installation of *x*-ray outfits in buildings where the price per square foot is high, this constitutes a very important item. Practically very little floor space is needed for the electric part of an *x*-ray outfit.

It is interesting to note also the large number of internists who have placed fluoroscopes in their offices, not with the idea of specializing in *x*-ray work, but simply wishing to have conveniently at hand an *x*-ray control of their physical findings. Here again, the simplified apparatus which has developed from war-time practice is conspicuous.

The problem of glass plates, their weight, and inherent danger of breakage, caused all who had to deal with military *x*-ray supplies to welcome the *x*-ray film. A cursory survey of the different laboratories in the country shows that the film has replaced the plate in practically every laboratory.

The ability to mail films has been a great saving to patients and has been of much practical value in the referring of cases to different parts of the country.

In no other branch of *x*-ray development has there been greater progress than in literature. Before the war, American *x*-ray literature languished, overshadowed by the work of more prolific writers from across the water. Since the war, however, American *x*-ray literature has come into its own; our *x*-ray journals have increased in size, quality and circulation; many books have appeared which are a credit to their writers, and we can point to them with a feeling of national pride. The large number of workers naturally furnishes a good market, which in turn encourages production.

Our society should foster in every way this outcome of the war, and not allow foreign publishers again to monopolize the field. The opportunity came and was seized upon; let us not now lose it.

With this advent of standardized technique, we must not forget that we should turn our attention to standardization of methods of roentgenologic teaching, and that we should urge upon the different medical colleges of the country the necessity of a more uniform curriculum in *x*-ray work. It is undoubtedly true that there is coming a period of readjustment in methods of medical education. There is a feeling that there is too much memorizing of known but infrequently applied knowledge. The type of instruction must

change from the highly theoretical to a more practical cast. If we do not insist that our own specialty receive proper recognition, it may happen that the change in the curriculum which will soon come about, will not accord to roentgenology its proper place. We, accordingly, as a well-recognized and influential society, should seek to extend these post-war influences, so that they may be perpetualized through proper medical education.

In conclusion, it may be said that the sacrifices and hard work of the roentgenologists during the war have not been without reward in a great broadening of the field of roentgenology, and that any survey like this, however incomplete, can only be made with satisfaction that the work has been so well recognized.

DISCUSSION

DR. CHRISTIE. I have practically nothing to add to Dr. Hickey's very timely paper. It seems to me it is a very timely paper, because it brings to us a resumé of the things that happened during and since the war. Many of us had great misgivings during the war about what was to happen to roentgenology as a specialty because of the great number of men who had to be trained for *x*-ray work during the war. It seemed that the small amount of training that so many men received would turn loose on the country very many poorly-prepared men. This misgiving was not very well founded, because those who were not well trained, and who had little ability for advancement in this specialty have dropped out. There have been added to the specialty a very great many well-trained and excellent men. There are one or two points I wish to emphasize in Dr. Hickey's paper: One point that especially appealed to me is that the *x*-ray work in all our hospitals in the army did bring to the internist and surgeon appreciation of *x*-ray work which they never had before. It is certainly so in my own city. Very many men who knew nothing at all of the value of *x*-ray work before the war, came back after the war, and appreciated the value of this work. Besides that, it has a great influence in helping to stamp out, to some extent, the commercial laboratory, because the men who served in good post-hospitals during the war found out what good *x*-ray work was and were able to discriminate between the two. For that reason they are coming to men who are well-qualified roentgenologists. I believe with Dr. Hickey that the general effect of *x*-ray work during the war has been for the good of our specialty, and medicine in general.

DR. PIRIE. First of all, I wish to agree with Dr. Hickey on the effect of the war on the development of *x*-rays. It has popularized *x*-rays and has given us a great deal more to do. I looked for great developments from the war, and I found none. The great development is the popularity of the *x*-ray now, in comparison with what it was before. One development which has arisen and which I did not foresee, and is only coming now in my practice, is this: The army files which kept the history sheets were big folders; we use similar folders in hospitals in Canada, and since the introduction of films, I file the films away with the medical history in these folders, so that at any future date when I want the films, I get with them the complete history of the case. It is also an easy way of disposing of films.

I am going to disagree with Dr. Hickey in his statement that the short-sighted policy of the English did not supply good apparatus. Now, a good many of you do not know what the English did in the *x*-ray world. I saw 2,000 *x*-ray tubes waiting to be sent to France. We never failed to have *x*-ray plates when we wanted them. The apparatus we had did the work, and that was what we were after—to localize the foreign bodies and get the boys back to the front as soon as possible. No man was burned by the English apparatus during the war. Although we did not have extremely fine apparatus, it was war, and we wanted apparatus that would do the work.

Dr. LeWald, of New York, showed some lantern slides, and called attention to the work of the late Dr. E. W. Caldwell, and asked Dr. Hickey if any further development had followed in the use of the Caldwell Stereofluoroscope, and the bakelite canvas stretcher top. Dr. LeWald referred to the work of the late Prof. John S. Shearer and his associates, especially that of Captain Middleditch; and of the large number of roentgenologists (nearly three hundred) instructed in the New York School of Military Roentgenology, many of whom were present. He referred to the work of the instructors who remained in this country, and considered the relative importance of their work as essential to the winning of the war.

Dr. LeWald wishes to emphasize what Dr. Hickey said relative to the importance of the proper teaching of roentgenology in the Medical Colleges, as, otherwise, the full effect of the marked stimulus which resulted from the war might be lost.

DR. MANGES. I am sure we have all enjoyed Dr. Hickey's paper. Only Dr. Hickey could write a paper like this, and if we take the time really to study what he has said (and we cannot get it from just sitting listening to it) we will find that it has a great deal of interest for all of us. I have only a few words to say in discussion, and those because his paper has brought back to me impressions that I have had since the war has closed.

In the first place, there has been an increasing demand for instruction. More and more men are applying to the larger clinics for advanced instruction. I know that, because in the last few years I have had to turn away numbers of men who wanted instruction of one kind or another. I was so situated that I could not take care of many of them, and I have no doubt there are others with the same experience. Some of these men wanted to come for a term of months, or even for a full year. Just this one fact alone emphasizes what Dr. Hickey brings out in his paper—that is, the tremendous effect the war has had on our specialty.

Then there is another fact of importance: There is an increasing demand for trained or experienced roentgenologists. I have numerous letters on file, asking me to recommend such men for good positions. I have not been able to supply them, for the very good reason that every well-trained man is already established.

There is still another impressive fact. Before the war, our work came to us largely from the older and more established members of our profession, whereas now, a great deal of it comes from the young surgeons and internists who were in the service. Our clinics and laboratories are simply overwhelmed with requests for the study of the sinuses, chests, urinary and gastrointestinal tracts, and of all other parts of the body. These men learned during their service to depend a great deal upon the diagnostic aid of the roentgenologists of their organizations. Many of them had to face problems in camp life in this country, as well as at the hospitals near the front in Europe, such as they had never experienced in civil practice. In most of the camps there were epidemics, and in all of them there developed conditions in the chests of many of the officers and enlisted men who were brought from sedentary and more or less inactive lives into new surroundings, and were put to unusual exertion, so that many of them developed bronchitis or some degree of bronchopneumonia; others suffered from dilatation of the heart and a certain degree of pulmonary congestion. It was demanded of them that an early diagnosis be made, and they learned to depend a great deal upon the *x*-ray department—especially to rule on the question of pulmonary tuberculosis. Many officers and men who were suspected of being tuberculous cases returned to normal with rest after negative *x*-ray diagnoses. Now all those clinicians and internists are our warmest friends, and they are depending more and more on us to confirm or refute their diagnoses as to chest and other conditions.

I wonder if all of you really appreciate the amount and value of the teaching that was done during the war. Those of us who were actively engaged in it realize that we were trying to do something big, and if we did accomplish something—and I believe we did—it was largely due to the master-mind of Shearer, who was a born teacher and who knew our problems from A to Z, especially the electrical and mechanical problems. He directed every bit of the technical teaching that was done, that was of any value, during the war. We did not teach our individual ideas or hobbies. There was no place for that. Shearer had that insight as to what was needed, and after a little conference in New York, before we got actually started, we had practically mapped out the line of work that was to be carried out. I am sure that that teaching has had wonderful effect on the future of roentgenology. As to Dr. Hickey's recommendations for future teaching in the undergraduate schools, I think there is a great deal of thought to be given to that, and I am not prepared to discuss it any further.

DR. HICKEY (closing discussion). One thought was prominent in writing this paper: that when the Americans entered the war, they had the advantage of using standardized apparatus for *x*-ray diagnosis. I think it can be considered as settled beyond discussion that a military hospital which has the advantage of standardized *x*-ray apparatus will, in general, turn out better work than one not fitted with standardized apparatus.

It is to be hoped that out of this discussion will come a stimulus to our publication committee to elevate our journal in every possible way, so that it will be the leading roentgenologic publication in the world.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

FOURTH ANNUAL MEETING EASTERN SECTION AMERICAN ROENTGEN RAY SOCIETY

RITZ-CARLTON HOTEL, ATLANTIC CITY, N. J., JANUARY 25–27, 1923

MIDWINTER MEETING CENTRAL SECTION AMERICAN ROENTGEN RAY SOCIETY

SEELBACH HOTEL, LOUISVILLE, KY., FEBRUARY 24, 1923

CORRESPONDENCE

To The Editor:

In your April, 1922, issue, p. 247, Prof. Hazen has the following remark:

"At the present time I should be much inclined to feel that superficial cancers will yield much more rapidly to unfiltered than to filtered doses and that the very powerful types of apparatus that are now being developed will have no effect upon the prognosis of skin cancer."

This is not my experience. I irradiated a patient with rodent ulcer extending from the inner canthus of one eye to that of the other. Almost all of the nasal cartilages were eroded. Exposure, on July 20th last, to 60 minutes, 5 ma., 200,000 volts, filter 1.3 mm. Cu., and 1 mm. Al., skin-target 50 cm., led to prompt healing. The ulceration over the cartilages healed at once, the mucous membrane growing over it without any delay. The dose has been repeated only once (on Sept. 8th).

Yours faithfully,
H. Flecker.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page i of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to Roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

The meeting of the Eastern Section at Atlantic City promises to be of considerable interest, judging from the following preliminary statement.

PRELIMINARY PROGRAM OF MIDWINTER MEETING EASTERN SECTION A. R. R. S.

THURSDAY, JAN. 25, 8:15 P.M.

Localization of Brain Tumors by Cerebral Pneumography. Dr. Walter Dandy (By invitation), Baltimore, Md.

Discussion to be opened by Dr. Harry C. Kerr (By invitation), Washington, D. C., Dr. Foster Kennedy (By invitation), New York City, N. Y. and Dr. H. K. Pancoast, Philadelphia, Pa.

FRIDAY, JAN. 26, 9 A.M.

Some Preliminary Observations on Cardiac Measurements in Children. Dr. F. S. Borzell, and Dr. Ralph M. Tyson (By invitation), Philadelphia, Pa.

Discussion to be opened by Dr. H. K. Pancoast, Philadelphia, Pa.

Stereoscopy of the Accessory Sinuses. Dr. G. W. Grier, Pittsburgh, Pa.

Discussion to be opened by Dr. F. M. Law, New York City, N. Y.

Para-Articular Tuberculosis. Dr. Lawrence Reynolds, Detroit, Mich.

Discussion to be opened by Dr. Leon LeWald, New York City, N. Y.

Osteitis Fibrosa Cystica. Dr. Percy Brown, Madison, Wis.
Discussion to be opened by Dr. F. H. Baetjer, Baltimore, Md.
A New Tube Holder for Deep Roentgen Therapy. Dr. Edwin A. Merritt, Washington, D. C.
Discussion to be opened by Dr. W. H. Stewart, New York City, N. Y.
Roentgen Diagnosis of Deep Cervical Glands. Dr. Lewis G. Cole, New York City, N. Y.
Discussion to be opened by Dr. W. F. Manges, Philadelphia, Pa.
Roentgenographic Studies of Abscess of the Lung Treated Successfully by the Bronchoscopic Method. Dr. W. H. Stewart, New York City, N. Y.
Discussion to be opened by Dr. Leopold Jaches, New York City, N. Y.

FRIDAY, 2 P.M.

Secondary Signs of Gall Bladder Pathology. Dr. Ralph D. Leonard, Boston, Mass.
Discussion to be opened by Dr. Lewis G. Cole, New York City, N. Y.
Diagnosis of Obscure Abdominal Lesions by the Routine Gastro-Intestinal Examination. Dr. W. H. Dickson (By invitation), Toronto, Ontario.
Discussion to be opened by Dr. G. E. Pfahler, Philadelphia, Pa.
Further Studies in the Biology of Cancer Cells. Dr. Francis C. Wood (By invitation), New York City, N. Y.
Discussion to be opened by Dr. James Ewing (By invitation), New York City, N. Y.
Measurement of Dosage by Means of Ionization Chambers. Dr. William Duane (By invitation), Boston, Mass.
Discussion to be opened by Dr. Otto Glasser (By invitation), Baltimore, Md. *On Dosage Problems.*
Measurement of Ionization Produced by Scattered and Secondary Radiation Which is Effective in Producing an Erythema. Eugene Leddy, M. D., and J. L. Weatherwax, M. A. (By invitation), Philadelphia, Pa.
Discussion to be opened by Mr. G. Failla (By invitation), New York City, N. Y.

FRIDAY, 8:15 P.M.

The Diagnosis of Bone Tumors Based upon the Clinical History, Examination, X-ray and the Pathology as Exposed by Operation. Dr. Joseph C. Bloodgood (By invitation), Baltimore, Md.
Discussion to be opened by Dr. James Ewing (By invitation), New York City, N. Y., and Dr. F. H. Baetjer, Baltimore, Md.
Lantern Slide Exhibit

SATURDAY, JAN. 27, 9 A.M.

Statistics and Technique in the Treatment of Prostatic Hypertrophy by Means of the Roentgen and Radium. Dr. J. T. Stevens, Montclair, N. J.
Discussion to be opened by Dr. J. T. Geraghty (By invitation), Baltimore, Md.
Systemic Effects of Deep Roentgen Irradiation. Dr. James T. Case, Battle Creek, Mich.
Discussion to be opened by Dr. J. M. Steiner, New York City, N. Y.
High Voltage Roentgen Therapy in the Treatment of Carcinoma of the Breast. Dr. G. E. Pfahler, Philadelphia, Pa.
Discussion to be opened by Dr. Samuel Stern, New York City, N. Y.
The Treatment of Carcinoma of the Floor of the Mouth. Dr. Douglas Quick, New York City, N. Y.
Discussion to be opened by Dr. G. E. Pfahler, Philadelphia, Pa.

SATURDAY, 2 P.M.

Treatment of Carcinoma of Esophagus by Deep X-ray Therapy. Dr. Alexander Pirie, Montreal, Canada.
Discussion to be opened by Dr. J. M. Steiner, New York City, N. Y., and Dr. James T. Case, Battle Creek, Mich.
Results Obtained by Radiation (Radium and Roentgen Rays) in Malignancy of the Prostate and Bladder. Dr. J. T. Geraghty (By invitation), Baltimore, Md.
Discussion to be opened by Dr. H. G. Bugbee (By invitation), New York.
A Review of the Treatment of Hyperthyroidism by All Methods with a Résumé of the Authors' Experience with Roentgen Therapy. Drs. Thomas A. Groover, Arthur C. Christie and Edwin A. Merritt, Washington, D. C.
Discussion to be opened by Dr. George E. Pfahler, Philadelphia, Pa.
Business Meeting.—Election of Officers.
Annual Meeting of the Military Roentgenologists.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

BOOK REVIEWS

THE PHYSICAL AND TECHNICAL FOUNDATION FOR THE MEASUREMENT AND DOSAGE OF THE ROENTGEN RAYS, by Frederick Voltz. Supplement VI to *Strahlentherapie*, with 173 figures. Berlin, Vienna, Urban & Schwarzenberg, 1921.

This volume, consisting of about 300 pages, gives an exhaustive presentation of the physical nature of the roentgen rays, their measurement and dosage. The book is primarily intended for the physician, for the technician and for all those who work with *x*-rays. However, it presents a good amount of mathematical physics for the practitioner, so that he has to select the matter which interests him theoretically, and which is important for him practically.

For the purposes of this review, a few of the conclusions which are valuable for practical therapeutics have been selected. As direct measuring methods of the quantity of the roentgen rays, (1) the iontoquantimeter and (2) the selenium cell (Fürstenau intensimater) are of practical value. The first is also applicable for scientific purposes and for comparative tests, and gives the most reliable results. In the iontoquantimeter, the *x*-rays ionize the gases in a graphite chamber; through the ionization an electrometer connected therewith is discharged; the time of discharge is the measurement for the quantity of absorbed roentgen-ray energy. The unit of measure for the quantity of electricity generated in the chamber is "e" (Friedrich); its dimension is $cm.^{\frac{3}{2}} \times g.^{\frac{1}{2}} \times sec.^{-1}$. With this unit, a capacity of 1 cm. to 300 volts can be attained. The selenium cell of the Fürstenau intensimeter has the defect of selective absorption, which, however, is of little importance in the practical measuring of intensity and surface energy. This defect is still less important, because, in practice, the bundle of roentgen rays is filtered and the maximum of intensity is consequently shifted over to the region of the short wavelengths which lie beyond the absorption band of selenium. For that reason, the selenium cell can very well be employed for the purpose of comparing intensities, provided the conditions of roentgen-ray generation and the apparatus remain the same. To employ quantimetric and qualimetric methods at each irradiation is too cumbersome for the determination of the *x*-ray dose. Seitz and Wintz have therefore introduced irradiation according to time into roentgen therapy.

The mixture of rays of a roentgen tube is first measured quantitatively and qualitatively with some measuring device (most frequently the iontoquantimeter). For practical operation, the following factors must remain the same: (1) Tension on the line (voltmeter); (2) primary self-induction (measure of the degree of voltage); (3) the number of turns of the interrupting motor (tachometer); (4) secondary voltage (parallel spark gap measure of hardness of tension); (5) intensity of the secondary current (milliampère meter).

The radiation from the tube must be tested at definite intervals.

As a unit, is assumed the skin erythema dose (H.E.D.), or that quantity of rays which causes a slight reddening of the skin after eight days and a slight bronzing of the skin after fourteen days.

Provided the above-mentioned conditions are observed, H.E.D. is always obtained in the same space of time.

The skin erythema dose, H.E.D. which equals 100 per cent, must be brought into definite relation with Friedrich's electrostatic unite:

Skin erythema dose	= 100% H.E.D.	= 170 e.
Castration dose	= 35% H.E.D.	= 58 e.
Muscle dose	= 180% H.E.D.	= 306 e.
Intestinal dose	= 135% H.E.D.	= 230 e.

(The carcinoma dose = 110 per cent H.E.D. and the sarcoma dose = 70 per cent H.E.D. are not accepted as sufficiently established.)

The biological measuring method according to Jüngling seems destined to play an important rôle as a control of the physical measurements. Jüngling irradiated the germinating sperms of the vicia faba equina from the first to the second day of germination. He observed the injury caused by the irradiation and gave the following conclusions: (1) Arrest of growth after forty-five days without the formation of lateral radicles = H.E.D. = 100 per cent; (2) appearance of the lateral radicles at the tip of the radicles, dose = 60 to 85 per cent; (3) appearance of the lateral radicles in the center, dose = 40 to 53 per cent; (4) a delay of two days in the appearance of the lateral radicles, dose = 33 per cent; (5) no delay, dose up to 13 per cent.

A definite temperature (thermostat) is essential for working with this method.

TRANSLATIONS & ABSTRACTS

PETERSEN, WILLIAM F., AND SAELHOF, CLARENCE C. Roentgen-Ray Stimulation of the Pancreas in Experimental Pancreatic Deficiency. (*Am. J. M. Sc.*, Mch., 1922, clxiii, 3, 391.)

With roentgen stimulation of organs two distinct methods may be considered. The first would include the stimulation of dys- or hypofunctioning organs with the purpose of restoring function to the normal. The treatment of anuria in acute parenchymatous nephritis; hepatic intoxication in some forms of cirrhosis; achylia; anemia of certain types; particularly, endocrine disturbances—the ovaries in some forms of amenorrhea, the testicles, the hypophysis in growth disturbances, the adrenals in Addison's disease, the pancreas in diabetes; all these are examples of possibilities of the first method.

The second method includes the stimulation of normal organs and the augmentation of the serum enzymes, thromboplastic substances, antibodies, etc., therewith bringing about therapeutic effects on systemic or localized infections or other pathological processes. With this end in view experiments were conducted on partially depancreatized dogs and the following conclusions were drawn from the work.

In experimental pancreatic deficiency due to partial pancreatectomy, roentgen irradiation of the pancreatic rest may be followed by (*a*) a transient increase in sugar output, then by (*b*) an increase in carbohydrate tolerance. This latter may occur without the preliminary increase in sugar excretion, and the increased tolerance which may be transient or may extend over a period of several weeks after irradiation, therefore, not be due to the preliminary increase in sugar elimination. When increased sugar elimination is brought about by some other irritant (turpentine abscesses), no increase in carbohydrate tolerance is later observed.

The effect on the blood sugar varies. Usually a temporary increase in the blood sugar can be determined, followed by a lowering of the level from five hours to several days after the irradiation. When evidences of acidosis exist at the time of irradiation they may diminish or disappear with the improvement in the sugar tolerance.

The effect of irradiation of the pancreas is due to direct stimulation of cellular metabolic processes and not due solely to alterations primarily vascular. This stimulation is merely an example of the Arndt-Schulz observation that cell irritants in small doses stimulate metabolic processes. When the irradiation is used in too large a dose, injury to the pancreatic function is apparent in a diminution in carbohydrate tolerance. When tissues other than those containing the pancreatic remainder are irradiated, no effect is observed on the carbohydrate tolerance, other than the primary augmentation of sugar excretion. The titer of the serum diastases, which may be altered by irradiation of the liver, seems to be without influence on the tolerance.

HERRMANN, GEORGE R., AND BURROWS, MONTROSE T. A Hitherto Undescribed Tumor of the Base of the Aorta. *Arch. Int. Med.*, March, 1922, xxix, 339.

Tumors of the heart are very infrequent. Tumors of the aorta are even more rare. The tumor described took origin from the aorta and was attached to the heart.

A detailed history of the case is given, together with the roentgenographic findings. A 7-ft. roentgenogram of the heart showed a large, sharply-outlined circular shadow projecting to the right of the midclavicular line. The cardiac dimensions showed a marked enlargement of the right side of the heart. The autopsy findings were as follows:

"Heart: The organ is greatly enlarged, and a large tumor mass, the size of a large orange, is attached to the superior wall of the right auricle, to the tissue of the auricular septum, to the sides of the aorta and pulmonary artery. The attachments to the aorta and pulmonary artery are loose. The firm attachment is to the auricular wall. The fibrous tissue of the pericardium of the heart is continuous with the tumor. The muscle of the auricular wall beneath the tumor is atrophic and apparently not continuous with it. The attachment to the auricle does not appear to be a primary one, but secondary to the irritation of the tumor lying on the auricle. The heart with the tumor weighs 945 gm.

"The myocardium of other portions of the heart, aside from the hypertrophy, show nothing of interest.

"Lifting the tumor away from the aorta reveals the outer wall of the pouch, which is seen to be continuous with a tough cylindrical-shaped cord of tissue which passes directly to the wall of the tumor to disappear within it.

"This slender cylindrical-shaped cord is evidently the pedicle of the tumor, and, on close inspection, is found to be composed externally of a tough gray tissue like that of the aorta or one of the large arteries. It has, how-

ever, no evident open lumen, but its center is composed in places of a gelatinous, and in other places of a glistening gray, material. It measures 4 cm. long and ½ cm. in diameter. It looks like an occluded anomalous arterial branch.

"The tumor is ovoid in shape and measures 12 × 9 cm. It has a tough, hard outer wall and is filled with a greasy, necrotic material which everywhere glistens as if it contained crystals. A smear of this necrotic material shows large numbers of rhombic plates with notched corners. The outer tough wall is thickened at this point of insertion of the pedicle. Here there is a large necrotic fragile nodule which extends into and replaces a part of the soft greasy material.

"The remainder of the wall is thin. It measures from 1 to 2 mm. in thickness. This wall is seen to be divided into several layers: an outer one, resembling muscle in many places, a second fibrous-looking layer, and an inner layer which is in contact with the glistening greasy content. This last layer appears to be composed of a gelatinous material which in places is streaked and mottled with gray and yellow opaque lines and splotches.

"From the gross description alone it was evident, therefore, that the tumor was not of auricular, but probably of aortic, origin. It had arisen from an anomalous arterial-like branch of this vessel."

STEIN. Roentgen Treatment of Condylomata Acuminata. *Wien. klin. Wchnschr.*, 1921, No. 26.

In view of the fact that surgical treatment is not satisfactory in cases of broad, large condylomata acuminata, and that recurrences are frequent, Stein irradiated 14 cases of giant condylomata: of these he cured 6, and improved 5 considerably; but 2 cases were not influenced at all. The rapidly growing, cauliflower-like condylomata react promptly to irradiation. Smaller warts, occurring in groups, are resistant to irradiation. In contradistinction to other authors who employ hard radiation with zinc filters, Stein uses only 3 mm. Al. filters and irradiates once or twice, at intervals of six to eight weeks.

ADLER. Radiation of Carcinoma of the Uterus. *Wien. klin. Wchnschr.*, 1921, No. 26.

Even with radium treatment there is a primary mortality; septic infections occur after the intrauterine introduction of radium. Against exclusive radiotherapy in these cases, must be considered the fact that the patients frequently refuse to continue the treatment because they feel very well. Operation gives better results than radiotherapy, but it has come to the limit of its effectiveness. For this reason, the author recommends postoperative irradiation of these cases, but not radiotherapy in place of operation. He operates through the vaginal route because of the lesser mortality involved, and then he combines radium with *x*-rays. Radium is introduced immediately upon completion of the operation.

JOSEPH. A case of death following pneumoperitoneum. *Beri. klin. Wchnschr.*, 1921, No. 46.

A great many authors report favorable results with pneumoperitoneum, which may occasionally, where adhesions are present, even produce a good therapeutic effect. Least favorable is this procedure in diseases in the true pelvis; very frequently no help in diagnosis was obtained. Regarding accidents: Leschke reports a case of injury to the gut; in peritoneal carcinoma Teubern reports a case of oppression caused by pre-peritoneal emphysema, which extended up to the neck. According to the experience of Biernath, one should wait at least fourteen days after pneumoperitoneum before operating. The simplest technique is that which employs a dull needle with a double bulb, while the air or gas is propelled through a water bottle. Goetze recommends that the patient be placed on the right side and the pelvis be elevated. Under these circumstances the intestinal loops are avoided as they drop to one side following the force of gravity. Author reports one case of death out of a series of cases of pneumoperitoneum. This was caused by an embolus. In all probability there was an injury to the right common iliac artery which was situated right below the thickened abdominal wall, as a result of very marked scoliosis. The author recommends great caution in the employment of pneumoperitoneum in all cases where there are anatomical changes.

MENGERT. Prophylactic Irradiation with High Altitude Sun in Rachitis. *Deutsche med. Wchnschr.*, 1921, No. 24.

In the Municipal Infants' Home at Dresden, 18 nursing babies, in whom rachitis, in all likelihood, would have developed later, were treated prophylactically with artificial high altitude sun. Among these were 10 premature births, 5 suffered from disturbed nutrition, 2 were congenitally luetic and one had been brought up by a wet nurse. Only the latter already showed evidence of rachitis. Irradiation was carried out from the first to the second month. The results after the conclusion of irradiation were excellent. The exceptionally brilliant cure in the almost unavoidable rachitis of premature birth was particularly striking. The clinical observations were controlled by roentgen

examinations. Technique of the treatment: 30 irradiations in all, each irradiation followed by an interval of two or three days, alternately front of chest and back; in the beginning, three minutes at a distance of one meter. The dose is then increased by three minutes until fifteen minutes are reached, retaining the same distance. After several exposures, the distance is decreased by 10 cm. until 70 cm. is reached. Thereafter, at 70 cm. distance, the time of exposure is again increased by three minutes up to thirty minutes, which is the maximum time of exposure.

RÜPPEL. Hilum Tuberculosis in Adults. *Med. Klin.*, 1921, No. 29.

The general symptoms of tuberculosis of the bronchial lymph-nodes are not characteristic. Percussion and oscultation frequently leave us in the lurch. On the other hand, the *x*-ray findings show, in cases of tuberculosis of the bronchial lymph-nodes, massive changes, and at one stroke clear the picture of the disease. As a matter of differential diagnosis, it is important to bear in mind the swelling of the bronchial nodes which occurs after grippe and continues for some time. Comparative exposures must be made at regular intervals. If one sees some of the enlarged bronchial lymph-nodes disappear after a few weeks, them one can assume that it was a case of grippe.

CAMP, O. DE LA. Radiation Treatment of Tuberculosis. *Med. Klin.*, 1921, No. 48.

The author emphasizes the importance of light for the life of plants and animals, and recalls the light cults of the old nature religions, the helioses of the Greeks, the solaria of the Romans, and the sun-cure mountains of the ancient Germans. The biological effect of the administration of light rests mainly in the skin. The action of the pigment is that of a protector against light, a sensitizer, and transformer of light energy, but also as an accumulator of heat and a regulator of transpirations. In the blood, the effect of light is shown in the increase of the function of hemoglobin, of the oxidizing processes and in lymphocytosis. Metabolism is increased by the effect of light, respiration becomes slower and deeper. Roentgen and radium irradiation cause, in general, the same biological effects. They penetrate, however, more deeply and have a varying effect on the different tissues, the normal as well as the pathological. In the battle with tuberculosis, radiotherapy attempts to assist the body. At all events, it must never do harm. Functional stimulation of tissue may, in general, be considered a process of healing, but the transition from the destruction of tuberculous tissue to the stimulation of the connective tissue is in a state of flux. For that reason, it is wrong to speak of a uniform tuberculosis dose. While in tuberculosis of the skin, local treatment with Finsen and Quartz light should be employed in addition to roentgen and general heliotherapy, the more deeply situated tuberculous lesions of bones, joints and lymph-nodes are treated more successfully with local roentgen and radium radiation than with heliotherapy. In pulmonary phthisis, the roentgen rays are effective in the non-progressive and non-destructive, in the afebrile and not in the pneumonic and exudative forms; but the cooperation of all these curative measures is necessary. In conclusion, the author emphasizes the value of prophylaxis, of the care of the young in the battle against tuberculosis, and prays to Mother Sun to aid us.

SCHWARZ. The Diminution and Increase of Radiosensibility of Animal Tissue and their Importance for Radiotherapy. *Münchcn. med. Wchnschr.*, 1921, No. 25.

The author demonstrated, in 1909, that skin which has been made anemic by pressure is considerably less sensitive to *x*-ray and radium irradiation than skin with normal circulation. Per contra, he also reports, that by hyperemia or by inducing inflammation, he has been able to bring about more intensive effects of the roentgen rays, that is, greater sensibility. For that reason, he considers as injurious too large portals of entry or too intensive doses, because they cause injury to the blood and disturb the production of leucocytes. He, on the contrary, wishes to produce a leucocytosis to facilitate the healing of tumors. For this purpose, one may use diathermy (Meyer, Theilhaber, Chr. Müller). Meyer and Behring have demonstrated that testicles of guinea-pigs which have been diathermized, have shown aspermia after smaller *x*-ray doses than those that have not been diathermized. Weinstein has employed, in cases of inoperable carcinoma of the cervix, constant hot vaginal douches in conjunction with roentgen treatment. The author recommends that the early reaction of the *x*-rays should be utilized, because, in his opinion, they represent an expression of the destruction of lymphocytes and tumor cells whose products of disintegration result in chemotaxic inflammation. The total dose should, therefore, be distributed over three days. Furthermore, the author has attempted to bring about specific inflammatory reaction by injection of products resulting from disintegration of tumors, and has seen several astonishingly good results, but also failures.

BORGGREVES. Roentgen Stereoscopy without Expensive Special Apparatus. *Münchcn. med. Wchnschr.*, 1921, No. 47.

Owing to the very high cost of stereoscopic apparatus, the author recommends the following simple method: Stereoscopic exposure is made in the usual manner by shifting the tube 7 cm. for the second plate, but the position of the patient and the focus-plate distance remain the same. Stereoscopic examination is then made by placing one of the exposures with the film side against the illuminating box, the other exposure with the glass side. A very black *x*-ray plate or a glass mirror which has its coating on the anterior surface is held in a sagittal direction in front of the forehead and tip of the nose of the observer. While the right eye sees the right sided exposure without any hindrance, the dark plate or the mirror reflects the left exposure in the reverse order; it must be held in such a position that the reflected image and the normal image overlap each other, producing plastic appearance.

WERNER. A Contribution to our Knowledge of the Generative Processes after Radium and Roentgen Deep Therapy. *München. med. Wchnschr.*, 1921, No. 25.

Out of 1,500 women treated by radiation for metrorrhagia or myomata, 17 became pregnant, several of them repeatedly, so that altogether, 24 cases of pregnancy after irradiation were observed. There were 9 abortions (3 of these were unquestionably induced), 14 normal births, and one total extirpation of the uterus on account of myoma. Six women, who for many months had become amenorrheic owing to irradiation, became pregnant again; in the other cases there resulted only oligomenorrhea. Of the 14 children born alive, 4 died, one immediately after birth, 3 at the age of one year from pneumonia or measles. The other children were under permanent observation. Of these, 3, which are now 6 or 8 years old, are 16 per cent below the normal in weight and 8 per cent below the normal in height. Two other cases were irradiated during pregnancy; in the first case, 4 roentgen irradiations were given; the child is normally developed; in the other case, there have been 4 treatments intravaginally with 30 to 50 mg. radium bromide, each treatment lasting twenty-four hours. The child, which was born at term, weighed only 2 kg. and was lacking in fat; its skin was pale yellow; it is now three years old; in height and weight it corresponds to two years, but is otherwise healthy. Irradiation of the ovum or of the embryo may, therefore, cause injury which, however, can be followed by extensive improvement in the course of later development.

FOERSTER. Clinical and Roentgenological Observations in Cases of Duodenal Adhesions. *Mitt. a.d. Grenzgeb. d. Med. u. Chir.*, 1920, xxxii, Heft 5.

Nine cases showed by history, clinical and roentgenological observations, symptoms which pointed to duodenal ulcer. The roentgen examination revealed always very active peristalsis. The duodenal bulb, in most cases, was very much distended; in 7 cases it showed marked residue after six hrs. It must also be noted that out of these 7 cases, 5 showed also a small residue in the stomach. Marked displacement of the first portion of the duodenum to the right and upward was frequently present. In most instances, the contour of the bulb was ill-defined and showed distinct bulging, twice even after direct filling through the duodenal feeding tube. All 9 cases were operated upon, but in none was a definite duodenal ulcer found, though in all there were fairly marked adhesions around the duodenum. The persistent shadows in the duodenum which had the appearance of niches were found to be projections in the wall. This leads the author to conclude that inasmuch as the entire symptom complex suggests duodenal ulcer, the symptoms mentioned in literature as suggestive of duodenal ulcer, may be caused entirely by adhesive processes. Only 2 of the cases showed primary ulcer; one had hemorrhages several years before; in the other case an old scar was found at autopsy. For this reason, the author leaves open the question as to whether the adhesions are caused by primary processes in the duodenum or by inflammatory processes of the neighboring viscera, for instance, the gall-bladder. Medical treatment was practically without result, but surgical procedure also failed to produce any lasting cure. Four cases examined after operation very soon showed new adhesions and presented old symptoms.

KARSHNER, ROLLA G. *X*-ray of the Heart. "*Southwest*" *Med.*, Oct., 1922, vi, 10, p. 362.

This is a very concise but instructive presentation of the present status of the *x*-ray examination of the heart. The author considers cardiac form, size and motion, the aorta, the various heart lesions, the heart of cardiac hypertrophy and hypertension and myocarditis, congenital lesions and neurocirculatory asthenia.

In myocarditis, two types are considered: Those without cardiac dilatation, including the senile type and the arterial sclerotic type (angina pectoris); and those with cardiac

dilatation, including the end stage of practically all valve lesions, the end stage of nutritional changes and the end stage of toxic changes.

In cases of the senile type, we see comparatively little enlargement. The position is transverse, usually considerably obscured by the dome of the diaphragm. There is an apparent lengthening of the arch with a prominent upper segment to the left. There is a low position of the auriculocaval junction. Occasionally we see associated senile emphysema and exaggerated bronchovascular shadows of the articulated type.

In myocardial degeneration with dilatation the area is increased and the outlines are variably altered. The shadow is obscured by a high diaphragm and, not infrequently, the increased density of adjoining lower lobes of the lungs. Often only enlargement can be determined. The cardiac movements are disorganized and lack in purpose and effectiveness.

In myocarditis due to hyperthyroidism there is moderate or no enlargement, the heart is shapeless, flaccid, the pulsations are futile, the impulse is not well sustained, there is tachycardia and generally a substernal goiter.

CARR, JAMES G., AND HANFORD, C. W. Carcinoma of the Esophagus with Perforation of the Aorta: Observations on Radium Therapy. *Am. J. M. Sc.*, Sept., 1922, clxiv, 3, p. 340.

Since the publication of Knaut, in 1896, 21 cases of esophageal carcinoma with perforation of the aorta or other large vessels have been reported. Another case is added by the authors.

Autopsy findings in the case here reported disclosed certain deficiencies in the application of radium therapy. Suggestions are made for more effective technique.

Fluoroscopic control does not necessarily mean treatment of the entire tumor. Under fluoroscopic control accurate measurements must be made as to the location of the tumor and its length. It is not enough to insert the radium from above. Until the tumor, for its entire length, is permeable to a sufficient degree to admit the capsule, so that the capsule may be passed the entire length and redrawn into the area, to be located at different levels, we cannot feel that our technique is directed to the treatment of the accessible growth in its entirety.

CAMPBELL, DON M., CARTER, JOHN M., AND DOUB, HOWARD P. Roentgen Ray Studies of the Nasolacrymal Passageways. *Arch. Opbth.*, Sept., 1922, li, 5, p. 462.

By *x*-ray studies the authors have been able to demonstrate on the living subject:

1. That the nasolacrymal duct and sac may have a side-to-side joining.

2. The passageways on one side may be very malformed and irregular in their course, while those draining the opposite eye may be regular in contour.

3. The passageways in the black race are, as a rule, much wider and more regular in outline than are found in the white race.

4. The lacrymal sac may, as the result of infection and obstruction, be extremely dilated, or again, it may be very small and contracted, and also, there may be fistulae leading from the sac.

5. By the method herein described it is possible easily to demonstrate the position which the lacrymal passageways occupy relative to the middle turbinate.

It would seem that we are justified in concluding that satisfactory *x*-ray data on the nasolacrymal passageways, showing the point of obstruction, the size of the sac, and its position relative to the intranasal structures is of practical value in that it allows us to make more accurate diagnoses, and to plan our relief with greater precision.

QUICK, DOUGLAS, AND JOHNSON, FRED M. Cancer of the Larynx Treated by Radium. *N. York State J. M.*, Oct., 1922, xxii, 10, p. 462.

This report of experience at the Memorial Hospital, New York, must be regarded as incomplete experimental evidence. Nevertheless, results to date give definite proof of the value of radium in these cases. Technique has changed so radically in late years that, in comparable cases, the work of today cannot be compared with that of one, two, or five years ago, and the literature gives very few data of value.

A considerable percentage of intrinsic growths are inoperable when seen by the laryngeal surgeon. In applying radium to a laryngeal growth, certain difficulties arise which are not met with in other parts of the body. If efficiently applied, radium creates a sharp inflammatory reaction of several weeks' duration, and, in the cases under discussion, this reaction is just at the vantage point of two body systems. It often interferes with both swallowing and breathing. Hence the danger of impairment of the patient's general health, which is usually already undermined. It is impossible to put the treated part at rest, and consequently the factor of mechanical irritation is added. It is very frequently impossible accurately to determine the extent of the disease in these cases. Vision alone is not sufficient aid in satisfactorily examining a malignant growth. Palpation, to

determine the depth of neoplastic infiltration, is most important; but, except for a few extrinsic lesions, this is impossible in laryngeal work.

The inflammatory reaction causes pain, and may interfere with swallowing and breathing as a result of edema. In bulky extrinsic growths, sloughing and hemorrhage must be reckoned with. A tracheotomy may be necessary before beginning treatment, or may become imperative. If only palliative relief can be hoped for, then the patient's physical comfort demands first consideration.

If a pack of sufficient amount of radium is not available for external application, then efficient *x*-radiation should be used as a second choice. The authors, however, prefer heavily filtered radium applied over both sides of the neck directly toward the primary growth. For external treatment, the greatest advance has been through the introduction of radium emanation tubes directly into the growth through fine trocar needles under local anesthesia. There is some danger from introducing mixed infection deeper into the tissues; but this is slight, especially if care be taken to avoid introducing through ulcerating surfaces. The glass emanation tubes have not given any trouble as foreign bodies, being either expelled or expectorated with minute particles of slough, later on, or buried in scar tissue. Tubes of small individual values should be used, approximating 1 mc. each. In selected cases of localized, relatively superficial growths a small glass bulb, 6 to 8 mm. in diameter and containing 500 or 600 mc. of emanation, is applied, mounted in a protecting metal cone with paraffin. A few minutes of this unfiltered irradiation is sufficient.

Surgery has been combined with irradiation wherever it seemed reasonable, particularly laryngofissure as a means of more accurately exposing deeply infiltrating growths.

A long series of valuable statistics is given. The authors conclude that, while the treatment of primary, operable, intrinsic cancer of the larnyx is permissible, we have no evidence thus far to justify advocating it as the agent of choice. The authors believe that the pre-operative use of radium in operable cases adds materially to the end-result. Radium should be withheld in the very advanced cases.

GLASS. Development of X-ray Plates in Bright Light (Safranine Method). *Deutsche Med. Wchnschr.*, 1921, No. 34.

Previous attempts to develop roentgen plates in bright light were not successful, because, either the plates were fogged, or they could not be removed from the developer for observation. Lüppo-Cramer reported a new method of development in a pamphlet entitled "Development of Negatives in Bright Light (Safranine Method)." The author has tested this method and recommends very strongly its employment. The principle is that by immersion of the exposed plate in a solution a phenosafranine before developing, or by the addition of this solution to the developer itself, the plate, which has hitherto been sensitive to light, becomes desensitized so that bright yellow light or candle light cannot harm it any more. The following is the method of procedure: 10 cm. of a stock solution of phenosafranine 1:2,000 are added to each 100 cu. cm. of developing solution; the plate is immersed for one minute in this solution, and can then be developed under the yellow or candle light. The other method is to bathe the plate under red light for one minute in a phenosafranine solution of 0.05 per cent, and to develop the plate in bright light in the ordinary solution, the plate must then be thoroughly rinsed before developing. The author's tests have shown that a perfect negative, free from fog, can be obtained, if the plates are treated with phenosafranine before the exposure is made, or after the exposure but immediately before developing. With glycin, developing becomes somewhat slower, owing to the impregnation of the emulsion with safranine. As a source of light, he employs a 32 candle-power electric bulb filtered through a tartracin gelatin film. The advantage of this method, according to the author, rests in the fact that the negative can be judged at the beginning of the development.

BÖTTNER. Roentgen Therapy of Polycythemia with Special Consideration of the Question of Cure. *Deutsche med. Wchnschr.*, 1921, No. 27.

In a previous communication, the author reported the cure of a patient with pronounced polycythemia (enlarged spleen, typical changes of the skin and of the mucous membranes, 145 per cent hemoglobin, 9,800,000 red cells). The successful result of the irradiation so far has lasted for one and a half years. In 2 further cases of polycythemia, the roentgen deep therapy of the bones and of the spleen did produce a return of the red cells to normal, but did not bring about a cure, as in the previous case. There is no cure, if, after a cessation of the increase in red cells, the normal erythrolysis does not suffice to cause their diminution. Roentgen irradiation then has no curative, but merely a symptomatic effect. It is possible that the blood-vessels which have acquired a compensatory dilatation have, in the course of years,

lost the ability to return to normal and cause a compensatory increase in erythrocytes. At all events, the author believes that the optimism regarding roentgen therapy in polycythemia is not justified, inasmuch as in several cases the roentgen rays have only a symptomatic effect.

KOHLER. *X*-ray Treatment of Pathological Fractures. *Deutsche med. Wchnschr.*, 1921 No. 26.

In the case of an elderly woman who had a pathological fracture of the femur due to metastatic carcinoma from the breast, the fracture was treated with small doses of *x*-ray. The fracture healed, but the tumor continued to grow rapidly. This goes to show that small stimulating doses cause growth, not only of the osteoblasts, but also of the tumor cells. Thereupon, 2 similar cases were treated with large doses. Technique: Large distant fields, two portals of entry, 18 by 14 cm., 50 cm. focus-skin distance, one skin unit dose each, 0.5 mm. zinc filter and 3.0 mm. Al. filter. Inasmuch as the surface of the upper arm is too small for the large distance field irradiation, it was wrapped in moist cellulose in a manner similar to that which Jüngling has described for bolus alba. In both cases the result was sclerosis of the bone and healing of the tumor by ossification. Cachexia ceased; after several months the patients who formerly had been very cachectic, gained a perfectly healthy appearance. In one case there was metastatic carcinoma of the neck of the femur, in the other case metastatic sarcoma in the head of the humerus with numerous pulmonary metastases.

BASCH. Roentgen Irradiation of Inflamed Sweat Glands in the Axilla. *Deutsche med. Wchnschr.*, 1921, No. 31.

Sebaceous and sweat-glands are extremely radiosensitive organs of the skin which undergo degenerative changes after weak irradiations and atrophy after strong irradiations. In most cases, the effect of the irradiation is shown after a few hours in the remission of pain, followed soon by the retrogression of the infiltrations or of the abscesses. In large abscesses the puncture incision is sufficient to bring about a cure. The author employs in every stage of the disease hard radiation filtered through 4.0 mm. and administers 15X = 1½ S.N. If after ten days, infiltration rests are still present, the same dose of radiation is applied again. The author considers in these cases, roentgen treatment as the therapy of choice, since, in a simple manner it produces healing of the disease by attacking the cause. He obtains this result in a much shorter time than by other methods of treatment.

LEXER. Treatment of Surgical Tuberculosis. *Deutsche med. Wchnschr.*, 1921, No. 29.

Surgical treatment of localized tuberculosis must be thorough; the author warns against insufficient procedure. There are frequently presented for treatment, cases which have been protracted too long under conservative treatment or have been made worse by insufficient surgical procedure. Synovial articular tuberculosis should be operated upon, if the tuberculous granulations become purulent, if pathological articulations occur, or when fistulae may cause putrid or general infection. In cases of articular tuberculosis affecting the bones, conservative treatment should be attempted only in children. Lexer operates upon every case of bone tuberculosis, if sequestra which are easily within reach, continue to cause abscess formation. In more deeply situated foci he employs the old method of treating the abscess by puncture and injection of iodoform-glycerin. In cases of tuberculous spondylitis, he incises abscesses only when they arise from a vertebral arch whose diseased portions can be removed, or when compression myelitis does not recede under traction. The author does not employ Albee's operation. Large tuberculous lymph-nodes, which are not adherent to the surrounding tissues, are cured by operation and postoperative radiation. As the principal means of conservative treatment, the author mentions sun baths at high altitudes and roentgen therapy; but even in the lowlands, sun treatment can produce good results and should in the winter be replaced by "artificial altitude sun." Roentgen irradiations cause tuberculous granulations to shrink and to form scars, and stimulate periosteal new bone formation in bony tuberculous foci. In cases of tuberculosis of the vertebrae, the roentgen rays will, in a few months, produce complete rigidity. The pressure pain disappears immediately. On the average, six months are required to produce complete rigidity of the spine. In cases of articular tuberculosis, especially in children, not only cure, but also mobility of the joints is produced. In cases of bone tuberculosis, the short tubular bones react particularly well. In such cases, Lexer had remarkable results in children. In adults, irradiation of larger foci in the spongiosa and in the bone marrow was completely ineffectual. The determination of the correct dosage of roentgen rays is not easy, even for experienced roentgenologists. With too large doses, scar formation does not occur, but there is a purulent breaking down of the granulation tissue. Tuberculous lymph-nodes should

be treated experimentally by stimulating doses, so as to cause their disappearance. If the enlarged nodes adhere to one another by periadenitis, diminution by scar formation cannot be expected, because we are dealing here with encapsulated large caseous masses. By larger doses such nodes can quickly be made to form abscesses. Abscesses should be evacuated by puncture before irradiation. Iodoform-glycerin should not be injected as long as the patient is under treatment. (Haenisch of Hamburg saw in 2 cases of abscess of the nodes which were on the point of rupture, extensive ulcerations, which, however, gave no sign of roentgen ulcer, and which healed with the formation of granulation tissue. He emphatically warns against irradiation in cases in which the skin over the abscess has already become thinned out by the inflammatory process. After rupture has occurred, small dose radiation is indicated. Note of the Reviewer.)

LASCH. The Effect of Artificial High Altitude Sun on Metabolism (Alpine Lamp). *Deutsche med. Wchnschr.*, 1921, No. 36.

As a result of his experiments in metabolism, the author found that the rays of artificial high-altitude sun produced in rachitic children a very markedly increased retention of calcium and phosphorus, and that this increase continued for some time after the process of healing had terminated clinically. Particularly remarkable was the rapidity of onset of this effect of the artificial high-altitude sun. He concludes that in rachitis the process is one of disturbance of the intermediary metabolism. A similar effect, with equal rapidity of onset, was observed by Schabad, some time ago, in his experiments on metabolism with cod liver oil.

RAUSCHBURG. Two Cases of Hypophyseal Dystrophia Adiposogenitalis and Their Treatment by Means of the Roentgen Rays. *Deutsche med. Wchnschr.*, 1921, No. 43.

Two patients with adipose dystrophy and with tumors of the sella turcica were treated with roentgen rays because of the presence of very severe manifestations of brain symptoms. After several months, there was marked improvement, which lasted during the nine months of observation. In the first case, which was that of a nineteen year-old student, there were, in addition to the symptoms of adipose dystrophy, severe changes in the region of the sella, diminution of vision as the result of increasing papillitis, attacks of vertigo and intolerable headaches. Four months after irradiation the manifestations referable to the tumor had disappeared, and after nine months the condition of the patients was very satisfactory; the choked disc had been cured, leaving no defect; the childish mental state had disappeared; the mental facilities had been considerably improved. In the second case, that of a fifty year-old woman, there was total blindness, enlargement of the sella, nausea, insomnia, mental depression and loss of interest. Ten days after the first irradiation, vision improved, and the power of vision rose gradually to $\frac{5}{10}$. After a few months, the patient felt absolutely well physically as well as mentally. There were three irradiations. The examination nine months after the treatment showed that the condition was still as favorable, without the slightest change for the worse. In both cases, the repeated intensive irradiations had destroyed the tumor tissue, but at the same time had no injurious effect upon the psychological and other functions of the brain.